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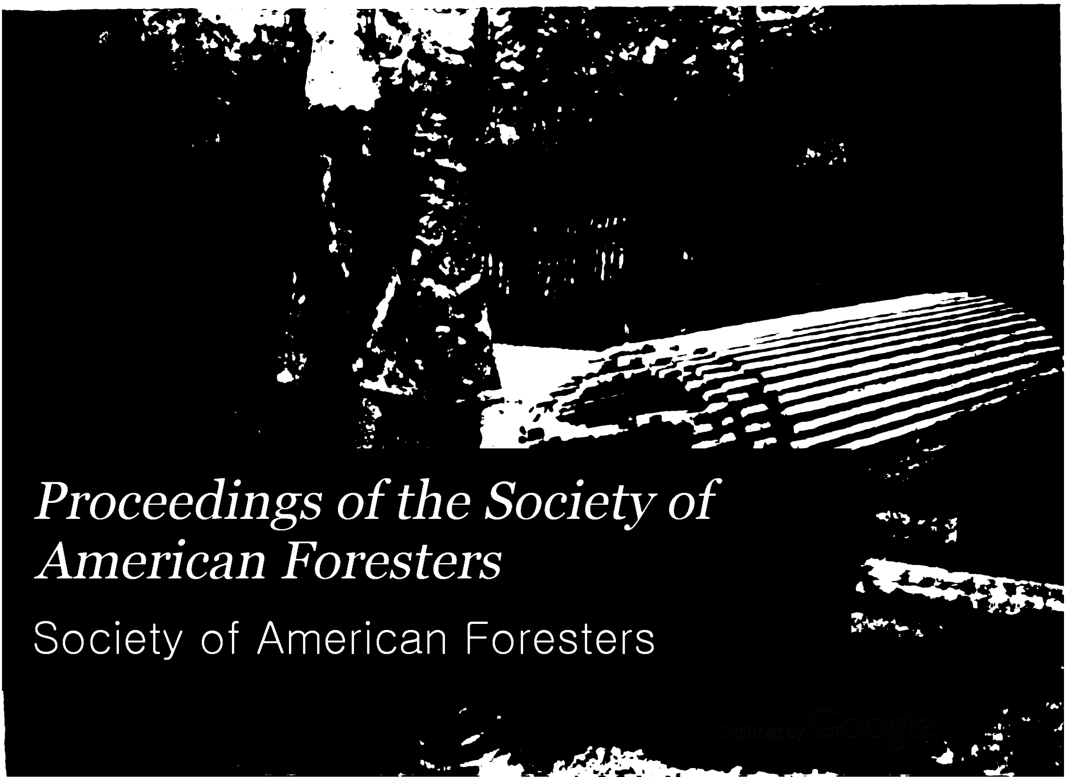
FIG. 1.—PROTECTION AGAINST WEEDS AT BRUCK



Proceedings of the Society of American Foresters

Society of American Foresters

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January, 1914

THE SOCIETY OF AMERICAN FORESTERS

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PROGRAM OF MEETINGS, 1913-1914

1913.

October 9. Open Meeting. The Scientist, the Editor, and the Public. Herbert A. Smith.

November 6. Open Meeting. What should be done with the chestnut stands in southern New England. J. W. Toumey.

December 4. Open Meeting. Turpentine possibilities on the Pacific Coast. C. Stowell Smith.

The conservative management of a National Forest for naval stores. Inman F. Eldredge.

1914.

January 14. Open Meeting. Methods of studying yields per acre on the basis of age for all-aged stands. Herman H. Chapman.

January 22. Annual Executive Meeting.

February 5. Open Meeting. The Marking and Management of Lodgepole Pine. D. T. Mason.

PROCEEDINGS

OF

THE SOCIETY OF AMERICAN FORESTERS

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VOL. IX JANUARY, 1914 No. 1

A GLIMPSE OF AUSTRIAN FORESTRY

BY THEODORE S. WOOLSEY, JR.

Contributed

INTRODUCTION

In the spring of 1912 the writer made a short tour in Austria under the personal guidance of Hofrat Petraschek. As a result of this trip certain features of Austrian forest administration appeared to be of such wide interest that they fully merited description; but before the data could be put in satisfactory shape considerable material then lacking had to be secured. The rough notes were therefore mailed to Hofrat Petraschek,[1] who with painstaking care and accuracy completed the data, corrected the statistics, rewrote most of the conclusions, and supplied new material from original sources. Consequently the article which follows should give an unusually clear and correct idea of certain phases of Austrian forestry which a mere traveler would be unable to present.

---

[1] The writer wishes to formally acknowledge his very great indebtedness to Hofrat Karl Petraschek in the preparation of the article which follows. This indebtedness is not only for the correction of the statistics but to a considerable extent for the conclusions and phrasing, since he kindly reviewed and corrected the original manuscript; much of the data, especially on "organization" and "personnel," is merely a translation of the redraft written by Herr Petraschek, who is now one of the highest authorities on Austrian forestry; but it should be understood that the writer is alone responsible for any errors which may have crept in. The help received has been so considerable that perhaps it would have been fairer to give Herr Petraschek's name as joint author. His retirement from active service enabled him to tour the United States in 1911, so that he thoroughly understands American conditions and is in a position to assist forest students who are planning to tour Austria. His present address is Munich, at 4 Friedrichstrasse. The writer is also indebted to Mr. and Mrs. A. Martinsen for translating Dr. Petraschek's critical notes.

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According to Dr. Fernow,[2] . . . "there is for the United States perhaps more to be learned from Austria in the matter of introducing forestry methods, especially . . . in Bosnia-Herzegovina, than from any other country." . . . Undoubtedly there is much that merits study: the development of virgin forests hitherto not placed under management, the natural regeneration under various conditions, the artificial regeneration of forests through sowing and planting, and especially the reafforestation of the arid Karst and other waste lands; the development of woodlands with a view to preserving springs which supply cities with wholesome drinking water; the control of torrents, as well as other everyday forest problems. Perhaps most instructive of all would be visits to the various privately owned estates, where the net profit in money must often be considered of paramount importance. Bosnia and Herzegovina are certainly worth visiting, to see how the problem of developing the forest resources of these countries by the introduction of modern methods of transportation has been so successfully solved by Hofrat Petraschek.

STATISTICS OF AUSTRIAN STATE AND FUNDS LANDS[3]

At the beginning of the last century the Austrian state and funds lands had a total area of 9,753,196 acres, which amounted to 13.1 per cent of the total area of the country. Financial embarrassment, caused by wars and other unusual circumstances, necessitated the sale of many state forests. Moreover, considerable forest areas were ceded to the peasants in lieu of rights. At the present time the area[4] of the state lands amounts to 2,819,330 acres, and that of the funds-lands 984,733 acres, or a total of 3,804,063 acres—little more than one-third the area at the beginning of the last century. This includes:

	Acres
Forest	2,574,036
Fields, meadows, gardens	89,063
Alps, pastures	193,233
Other productive grounds	16,833
Unproductive grounds	930,898
Total	3,804,063

---

[2] History of Forestry, B. E. Fernow, pp. 152.

[3] The "funds-lands" (Fonds Güter) belong to the religious and educational institutions of sundry Austrian countries; they are, however, administered by the state. The Hungarian state and funds lands are not included in these statistics.

[4] The following conversion figures have been used: 1 crown = $0.203; 1 hectare = 2.4711 acres; 1 cubic meter = 35.316 cubic feet; 1 meter = 3.278 feet; $1.00 = 4.935 crowns; 1 acre = .4047 hectares; 1 cubic foot = .028316 cubic meters; 1 foot = .304794 meters.

The forests are chiefly situated in the mountains, as will be evident from the following table:

	Per cent
Between 0 and 900 feet	2.6
Between 900 and 1,800 feet	14.1
Between 1,800 and 3,000 feet	27.7
Between 3,000 and 4,500 feet	42.4
Above 4,500 feet	13.2

of the total forest area.

The forest area of the whole of the state and fonds-forest is stocked with the following species of trees:

	Per cent
Spruce	51
Silver fir	18
Larch	4
Pine of all species	3
Conifers, 76 per cent.	
Beech and hornbeam	20.5
Oak, chestnut	1.3
Ash, maple, elm, and softwoods	2.2
Broadleaves, 24 per cent.	

It is certain that the percentage of beech will decrease during the next century, since the low prices for fuel are putting a premium on conifers, such as spruce, larch, and silver fir, which yield a larger proportion of timber and sawlogs. There were already in 1900 some 1,526,996 acres under definite working plan procedure; 933,379 acres were handled on the basis of special instructions to govern cutting in the Carpathian Mountains, and 85,643 under provisional cutting plans, making a total of 2,546,018 acres under plans, or 98 per cent of the total forest area.

At the present time there are everywhere definite administrative plans, of which two-thirds have been twice revised and one-third once revised.

Clear-cutting, in which each felling covers an area as small as possible, and shelterwood-cutting are the chief systems; 73.92 per cent of the total productive forest area is worked according to these two systems. Of the remaining forest area, 18.99 per cent is managed under the selection system and 6.59 per cent as protection forests where there is no cutting allowed; only 0.50 per cent is under the coppice system.

The total productive forest area is divided as follows as regards rotations:

A. By clear-cutting and shelterwood systems:

	Years
30.79 per cent on a rotation of	100
41.48 per cent on a rotation of	120
0.83 per cent on a rotation of	60–80
0.77 per cent on a rotation of	140–160

B. By the selection system:

	Years
13.04 per cent on a rotation of	130
4.16 per cent on a rotation of	120
0.16 per cent on a rotation of	80–100
1.11 per cent on a rotation of	160–180

The last official publication[5] for the three-year period—1901 to 1903, inclusive—gives some explanations concerning the financial side of the administration in the state and funds lands.

The following table gives the results of one year, calculated on the total productive area (2,853,165 acres):

RECEIPTS	$4,042,132	EXPENDITURES	$2,977,507
The value of the materials delivered to those having rights	319,926	Cost of administration	271,544
		Exceptional expenses for sanitation measures rendered necessary by damages caused by the heavy floods of the year 1899	193,217
Total	$4,361,058	Total	$3,442,268

The annual net proceeds of the above-mentioned period amount to $918,790, or $0.322 per productive acre, or $0.383 with the justifiable omission of the "exceptional expenses."

In order to do justice to the figures of these net proceeds, one must also take into consideration that, as already mentioned, the greater part of the state and funds forests are situated 3,000 feet above the level of the sea, where the transport of wood is carried on under all sorts of difficulties.

Moreover, from 1901 to 1903, inclusive, for various reasons, about 140,000,000 cubic feet less wood was cut than was anticipated by the administrative program.

During the past few years it would appear that the net proceeds are considerably higher than those previously mentioned, which is very plausible, since the price of wood in Europe is steadily on the increase. Some data on the costs of artificial reforestation in the Austrian state and funds forests may be of interest. These costs average $6.22 per acre.

The costs can be divided as follows:

	Per cent
Seeds	11
Plantations	35
Forest nurseries	30
Preparation of the ground	5
Care of crops	18
Cultural implements	1

---

[5] Jahrbuch der Staats- und Fondsgüter, Wien, 1907.

For labor alone the expenditure amounted to an average of $1.298 per acre if seed is sown, but $3.424 per acre if planted. Counting the cost of the seed, the stock from nurseries, all cost of cultivation and preparation, the purchase and depreciation of tools, the total cost of sowing amounted to $3.296 per acre and $7.963 per acre planted. The per acre extremes for sowing have been as low as $2.027 and as high as $8.361; for planting, from $5.151 and $17.356.

ORGANIZATION OF THE AUSTRIAN STATE AND FUNDS LANDS DEPARTMENT

The organization of the department under the Ministry of Agriculture at Vienna is shown by the skeleton diagram on page 12.

This skeleton survey[7] shows the relative position of the three main grades: 1. The forest protective service. 2. The administration in a narrower sense (local administration). 3. The direction (including control or inspection). Because the state and funds lands are scattered over a large extent of territory and because the local conditions in the various districts are very dissimilar, a fourth and central division became necessary, which naturally was located at the Ministry of Agriculture at Vienna. These first three divisions correspond roughly to the ranger force, supervisor's staff, and district offices in the West; the fourth division perhaps to the branch offices in Washington.

The greatest importance has been attached to the economic administration of the district. The duties of the forest officer in charge of each district consist in carrying out the forest management according to measures approved in the budget and in the various periodic plans, together with the bookkeeping which these involve. The youngest officers in charge of forests hold the rank and title of deputy forest supervisor or forest examiner (Forstverwalter) and the older ones the rank and title of forest supervisor (Forstmeister) or assistant district forester (Forstrat).[8] These officers have a staff of assistants selected from the forest protective and technical personnel, who are specialists in their lines of work; they have a right to pensions, but do not have the rank of those who carry on the forest management and direct the local supervision. These assistants can act for their chiefs in routine administrative matters. The younger assistants have the title of forest helper or forest guard (forstgehilfe) and the older ones the title of forester or "ranger" (förster). In a few forests of eastern Austria, still extensively managed,

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[7] Hofrat Petraschek furnished the material on organization, personnel, and education; consequently it is especially authoritative.

[8] See Forestry Quarterly, Vol. X, pp. 425.

IMPERIAL AND ROYAL MINISTRY OF AGRICULTURE IN VIENNA.[6]

Dep. X and XI.
Judicial and administrative agenda.

Dep. IX.
Technical management. Agenda report upon forest experiments. The holding of examinations for the Government technical forest service.

Dep. XII.
Legislation and administrative agenda. General data relating to forest and shooting laws.

- Examination and approval of the periodical departmental schemes and tariffs for the prices of forest products.
- General direction of the technical branches.
- Coöperation with all "committees" upon free delivery of wood, the stocking, and the use of forest products in general.
- Regulation of the wage tariff and other conditions of forest laborers from the technical and economic forest standpoint.
- Direction and supervision of the work of forest officers in general; examination of qualifications and recommendations for promotion of the same. Appointment of the forest officials from forest assistant upward.
- Service organization and regulations for the forest service.

Seven Forest Districts.

At Vienna, Gmunden, Salsburg, Innsbruck, Görz, Lemberg, Czernowitz.

- Maintenance of the property of the state and funds lands and the increase, as far as possible, of the revenues derived from them.
- Direction and supervision of the forest districts in accordance with the economic principles and departmental schemes established by the ministry, and also supervision of the free delivery and sale of wood. Administration and supervision of building. Direction and supervision of the shooting and fishing.
- Development of district working plans and their revision. Maintenance of the management work.
- The compiling of the annual reports and current accounts. The opening of credit accounts and advances of money, orders to subordinate branches, and supervision of the correct and appropriate expenditure of allotments. Supervision of the account and control branch. Appointment of forest pupils, forest assistants, foresters, etc.

196 "forests."

1,078 guard beats.

auxiliary guards are still employed without fixed appointments, solely for the protection of the forests.

The younger forest directors have the title and rank of assistant district forester (Oberforstrat), and those longer in the service the title and rank of district forester (Höfrat). The forest director (district forester) controls all the forests of the district under his administration, is the recognized head of the entire staff, controls the technical administration, as well as the bookkeeping, attends to the mercantile part of the business, in so far as it is not done by the forest supervisor, and represents his district at official gatherings. In order to accomplish this vast amount of work, the forest director has at his disposal a number of inspecting officers, of whom the younger in the service have the rank and title of assistant district forester (junior) (Forstrat) and the older ones the rank and title of assistant district forester (senior) (Oberforstrat). To carry out the administrative business, there are delegated to him besides a certain number of officers (assistant district forester and forest assistants or examiners), at whose head stands either an assistant district forester (junior) (Forstrat) or assistant district forester (senior) (Oberforstrat). There is, furthermore, at his disposal the necessary personnel for carrying out the projects for waterways, roads, and railways. He also has delegated to him the necessary officers and assistants for carrying out the legal administrative work, as well as the necessary accountants and clerks. The forest director has to submit more important cases to committees composed of his colleagues.

At the head of the departments of the Ministry of Agriculture are "Counselors of the Ministry" (Ministerialrat), bureau chiefs (whose rank is equal to that of assistant forester (Höfrat)). The technical working plans (Department IX) is especially manned with the necessary number of technical forest officers, with the rank of assistant forester and assistant district foresters (Hofräten, Oberforsträten, and Forsträten), to whom are deputed auxiliary technical forest officers, ranking as forest supervisors and deputy forest supervisors (Forstmeister and Forstverwalter). It should be clearly borne in mind that the organization is similar to an army where titles do not always correspond to responsibility; for example, an officer with the rank of assistant district forester might be in charge of a forest.

SALARIES OF THE AUSTRIAN STATE FOREST OFFICERS

The pay of the forest officers and their per diem allowances for journeys (exclusive of the compensation[9] for carriage and saddle-horses) amounts at present to:

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[9] This compensation is applied according to a special tariff.

Class of rank. (10)		Title. (Corresponding with military title and rank.)	Scale of salary.	Travel per diem allowances.
	V	Assistant forester (Ministerialrat and Höfrat) (Major General)	$2842 2436 2030	
Inspecting officers	VI	District forester (Oberforstrat and Forstdirector) (Colonel)	1786 1624 1462 1299	$3.25
	VII	Assistant district forester (Forstrat) (Lieutenant Colonel)	1299 1218 1096 974	2.64
Administrative officers	VIII	Forest supervisor (Forstmeister)[11] (Majors)	974 893 812 731	2.03[12]
	IX	Deputy forest supervisor (Forstverwalter=Oberförster) (Captains)	731 690 650 609 568	1.63[12]
	X	Forest assistants (Forstassistenten) (First Lieutenant.)	568 528 487 447	1.42

The advancement into a higher class, up to class VIII, inclusive, takes place by seniority. Advancement into class VII requires greater capacity, together with irreproachable performance of duty. Still higher demands in every direction are made for advancement into class VI, and the highest of all for advancement into class V. It requires three full years of service to be entitled to an increase of salary in classes X and IX and five years in classes VIII, VII, and VI. Officers of classes X and IX receive after sixteen years of completed service in one and the same class a personal increase in pay of $41, and after twenty years of completed service in one and the same classes such augmentation is increased by another $41.

---

[10] The Prime Minister is in class I, the Minister in class II, the Governor (political chief of the county) in class III, and the chief of section in class IV.

[11] As it is not always possible to allow capable and prominent administrative officers to enter into class VII by detaining them to special service with the forest direction, for the sake of common justice they are allowed to remain in their own administrative district, and nevertheless pass into the VII class.

[12] Only for journeys on duty outside of their district.

Over and above this, officers draw an increase in[13] salary for "activity," [14] which varies according to the rank class and within each rank class according to the locality of the service:

Class of rank.	Ministry of Agriculture and direction of forests, Vienna; also directions of forests at Cznernowitz, Lemberg, Innsbruck.	Directions of forests: Görtz, Salzburg, Gmunden; then four other forest administrations.	Six forest administrations.	The rest of the forest administration.
V	$446	$357	....	....
VI	374	299	....	....
VII	327	261	....	....
VIII	280	224	$196	$140
IX	244	195	170	122
X	195	156	136	97

Officers detailed on duty to the forest administration districts are given apartments there in government buildings.

SALARIES OF THE AUSTRIAN STATE SUBORDINATE FORCE

The auxiliary staff for forest protection and routine technical work is divided into eleven salary classes of $203, $219, $235, $251, $267, $284, $300, $316, $332, $349, and $365. The staff belonging to the four lower salary classes (1 to 4) receives the title of "forests helpers" (forstgehilfe); those in classes from 5 to 11 are called "foresters" (förster). The promotion into a higher salary class usually takes place after three full years of service. Promotion into the fifth class, together with the nomination to the title of "forester," however, only takes place if the "forest helper" has given, up till then, complete satisfaction in the discharge of his duty.

In addition to the salary, "forest helpers" as well as "foresters" receive an augmentation for activity, which amounts to 20 to 30 per cent of their salary, according to their official dwelling-place. Moreover, this staff is entitled to two increases (added to their pensions), which have been fixed at $20 for every four years of completed service in the higher grades of salary. The forest helper is also entitled to official quarters, the "foresters" to an official dwelling-house, together with stabling and firewood; garden, meadows, fields, and forest pasture are additional sources of income—certainly no small perquisites in a country where rent, fuel, and vegetables are so dear.

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[13] An increase in salary for activity is now being drawn up.

[14] Activity means active duty in the field or office.

PENSIONS OF THE AUSTRIAN STATE FOREST OFFICERS AND EMPLOYEES

Officers are entitled to a pension, which amounts to 40 per cent of their salary after ten years of uninterrupted service, and for every additional year of service 2.4 per cent, plus a fraction of their augmentation for activity, which is: $162 for class V, $130 for class VI, $114 for class VII, $97 for class VIII, $81 for class IX, and $65 for class X.

After the completion of 35 years of service, for instance, an officer who has been up till then conservator of forests in the highest grade of salary, receives as a pension his full salary of $1,786, in addition to the fraction of the augmentation for activity, amounting to $130, making the whole amount to $1,918. In case this officer should retire from active service on account of ill health, in the thirtieth year of his service only his entire pension will only amount to $1,666.

Officers who in consequence of illness or in consequence of bodily injuries have been rendered incapable of service before the tenth year of their service, who have, however, completed at least five years of service, are considered as if they had really served ten years.

Officers who have attained the age of sixty are entitled, at their own request, to receive the pension without furnishing the otherwise necessary proofs of incapacity for service.

The widows of officers of class V receive $609; class VI, $487; class VII, $365; class VIII, $284; class IX, $244, and class X, $303 as pension. The widows of "foresters" receive as pension one-third the pension the deceased husband would have received if he had been incapacitated; the minimum of a widow's pension, however, is $81. Besides these there are pensions for orphans, allowances for the education of children, and other similar benefices.

PRELIMINARY AND FINAL EDUCATION OF THE AUSTRIAN STATE FOREST OFFICERS AND "FORESTERS"

A candidate for an officer's billet in the state forest service in Austria must have successfully passed out of an upper "gymnasium" or an upper "realschule," and he must possess a diploma from one or other of them, showing that he has passed the final examination. Then he must attend lectures at the "high school for ground culture" and gain proficiency in the science of forestry, and in proof of this must pass the three state examinations.[15] If the candidate can prove by means of a government medical examination his physical capacities for forest service in the high

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[15] The student who besides can produce a dissertation and pass the so-called "rigorosa" obtains the Academic degree of "Doctor of ground culture."

PLATE I

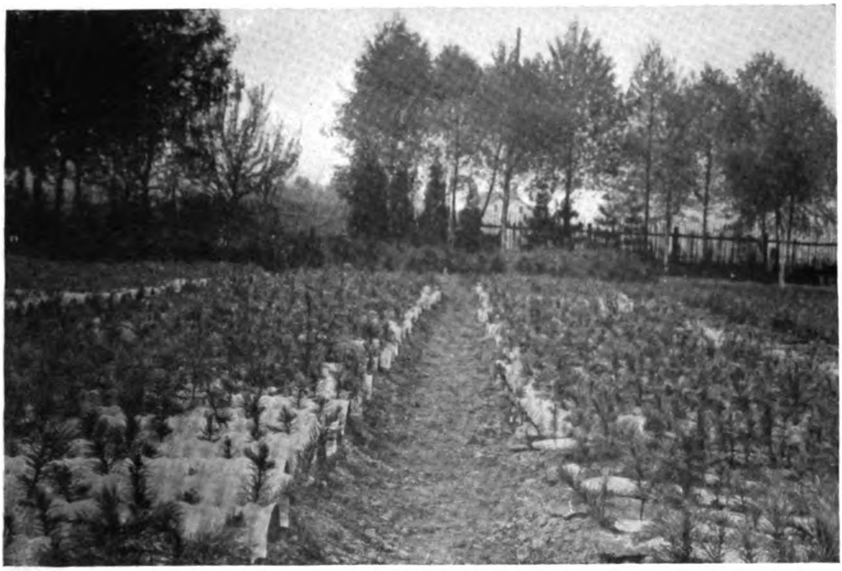

FIG. 1.—PROTECTION AGAINST WEEDS AT BRUCK

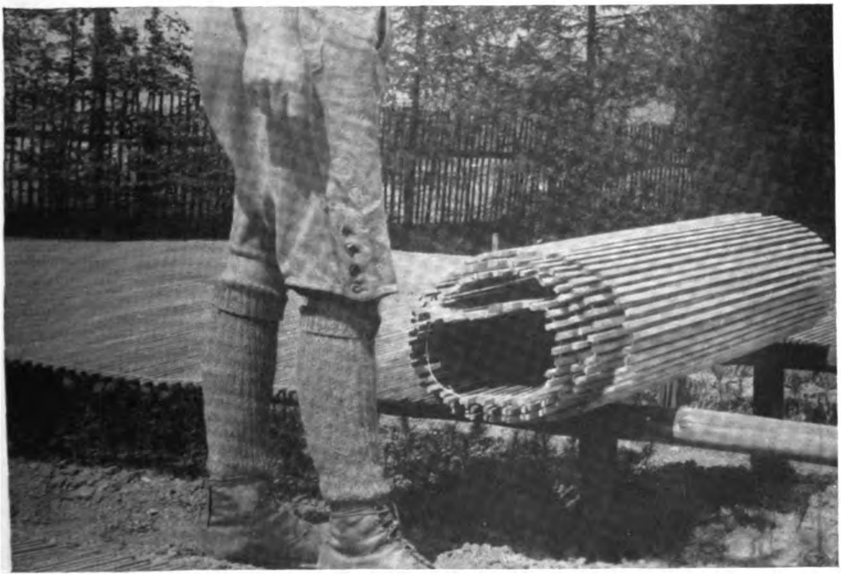

FIG. 2.—SHADE FRAME

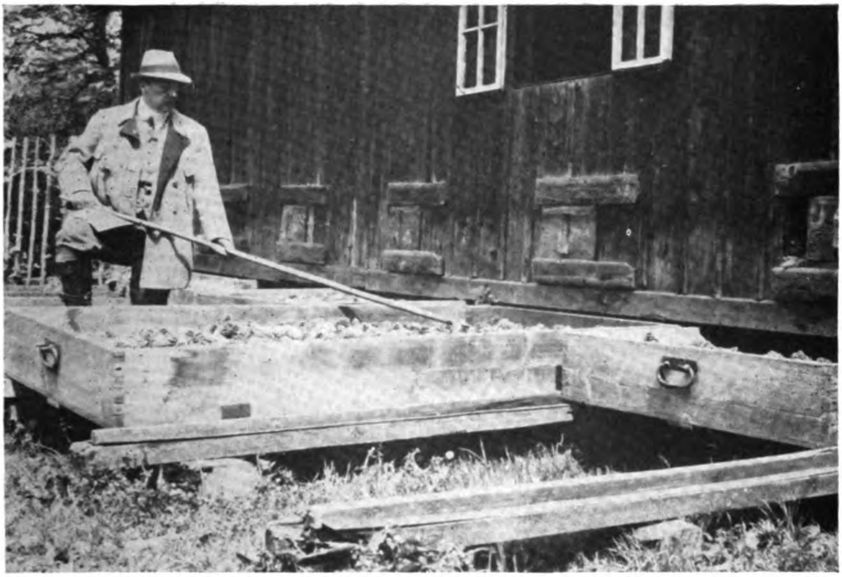

FIG. 1.—SEED EXTRACTION AT A RANGER STATION

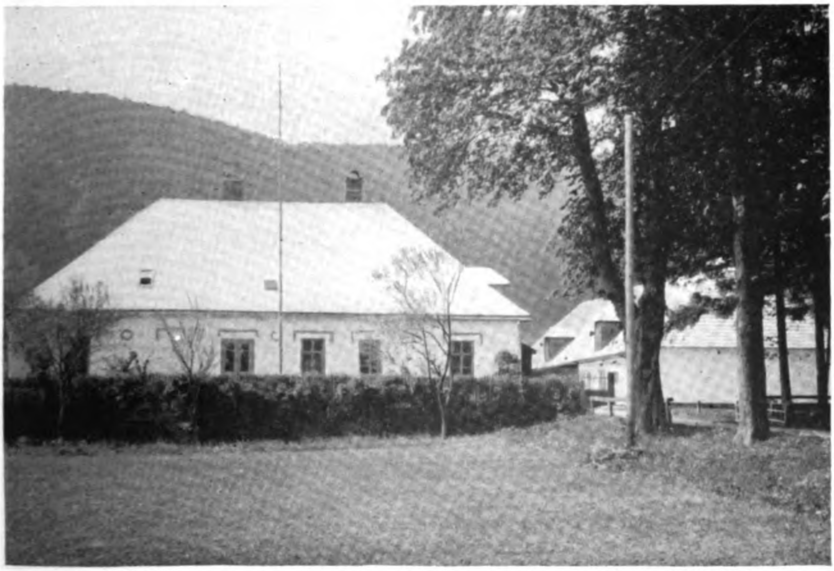

FIG. 2.—FOREST SUPERVISOR'S HOUSE. OFFICE AND LIVING QUARTERS

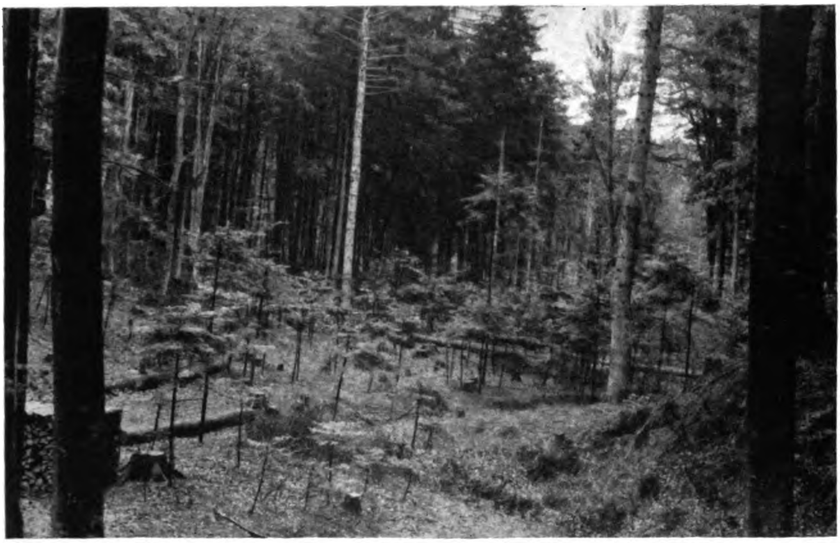

FIG. 1.—NATURAL REGENERATION OF FIR UNDER BEECH. (WIENERWALD)

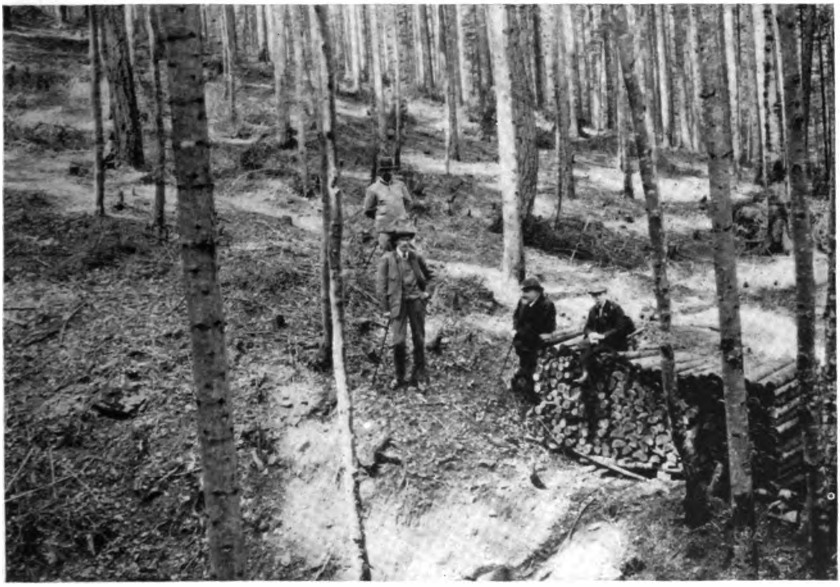

FIG. 2.—A SIXTY-YEAR STAND OF WHITE FIR AND BEECH AFTER THE FIRST THINNING. (WIENERWALD)

mountains, then his acceptance as a forest student takes place and he receives a yearly salary of $203. After at least three years of practical experience under the most varied circumstances of state forest service, the pupil must show his capacity to obtain a position in the state forest service by means of a special examination, which takes place first in the forest and afterward at the Ministry of Agriculture. Only after having successfully passed this examination can he be nominated as forest assistant in the X class. A period of seven years is, therefore, necessary for this training under favorable circumstances, for the studies at the high school for ground culture extend over a period of four years. If no billet of forest assistant is vacant, the pupil receives a yearly salary of $304.

The candidate for the post of "forest helper," and later as "forester" in the Austrian state forest service, must either have successfully passed through a complete course at the "burgerschule" or had three years' study at a lower "gymnasium" or lower "realschule."

Then he must show that he served a two-years' apprenticeship at a state forest establishment. He must also prove his physical fitness by a state medical examination. If these conditions have been complied with, then in the first instance he enters one of the four established state forest ranger schools (which have a course of eleven months). After successful examination (which generally takes place in the forest), the candidate is appointed as forest helper in the lowest category of pay.

FOREST EDUCATIONAL INSTITUTIONS IN AUSTRIA [16]

To those who wish to acquire the highest theoretical education in forestry the opportunity is offered at the high school for ground culture in Vienna (forest division), already mentioned. Preliminary education: Complete course at the "upper gymnasium," or complete course at the "upper realschule;" length of course, four years. Those attending lectures who present a dissertation and pass the so-called "rigorosa" examination receive the academic degree of "Doctor of ground culture." The high school for ground culture, where they have, also, an economic and a technical culture department, is maintained by the government.

For the training of capable forest officers for private forest property on a large scale (which, be it said incidentally, are for the most part admirably managed in Austria) there are the following private forest educational institutions: The forest schools in Lemberg (Salicia), Reichstadt (Bohemia), Pisek (Bohemia), and Mährisch Weisskirchen

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[16] The forest educational institutions of the Austro-Hungarian Empire in Hungary are not included here.

(Moravia), and for the Austrian Alpine district in the forest school in Bruck a. d. Mur (Styria). Preliminary education: At least five years in a "gymnasium" or a "realschule;" length of course, three years. The carefully planned educational courses of all these institutions are based upon the closest connection between theoretical education and practical field development. These establishments are maintained by subscriptions collected from the large forest proprietors and land-owners. Some of the larger proprietors have also their private forest schools to train their force.

In addition to the four government schools of forestry in Bolechow (Galicia), Gusswerk (Styria), Idria (Carinthia), and Hall (Tyrol), already mentioned, there are seven forest schools for forest helpers and technical assistant staff[17] for private forest proprietors and land-owners, viz, in Pisek (Bohemia), Budweis (Bohemia), Eger (Bohemia, Mährisch Weisskirchen (Moravia), Iamnitz (Moravia), Waidhofen a. a. Thaya (lower Austria), and Klagenfurt (Carinthia). Preliminary education: Complete course in a "burgerschule," or two classes in a lower "gymnasium" or a lower "realschule," and at least one year of practical experience in forest duties; length of education, one to two years.

In addition there are ten to twelve weeks' course for forest inspectors in Brienz (Voralberg), Rothholz (Tyrol), and Franzthal (Bukovina).

Two of the (already mentioned) forest schools for the education of forest officers for private proprietors of large forests were visited, viz, Bruck a. d. Mur (Styria) and Mährisch Weisskirchen (Moravia).

The forest school in Bruck a. d. Mur is under the direction of Dr. Rudolf A. Jugoviz. The equipment consists of a good fire-proof building, erected at a cost of $31,500, small botanical garden, and excellent nursery. A demonstration forest is under Dr. Jugoviz' direction. The classroom equipment was especially complete, and some of the graphic methods used could be readily applied in the United States. For the demonstration of planting methods large scale colored diagrams supplemented the lectures; all the different degrees of thinnings and reproduction systems were also graphically taught. Most interesting of all was the "operating table"—a very large box full of soft sand and numberless diminutive trees which could be stuck in the sand and used for demonstration. Other special equipment included models of lumbering, tapping, bridges, forest relief with triangulation stations, zoological collection, etc.; soil samples, fungus, insect, and botanical specimens. The demonstration forest and nursery will be described later.[18]

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[17] This should not be confused with the training for officers (superior staff) described above.

[18] As we left the building the students bid us adieu by singing some stirring forest songs; we had previously been accorded every hospitality by the director.

The forest school in Mährisch-Weisskirchen is under the direction of Dr. H. Reuss. Unfortunately, the school has no demonstration forest under its control, but possesses an excellent fire-proof building (cost about $37,800), nursery, and arboretum. In this school also there were exceedingly complete models of lumbering by gravity railroad; by splash dams; charcoal piles, showing method of piling; miniature wagons, with loads on; saw-mill models. In addition the usual botanical specimens, zoological collection, soil laboratory, and instruments of all description. Dr. Reüss is a planting expert, and in his class-room demonstrates the different methods of planting and the use of the various special planting boards, tools, etc., in a large box filled with moist sand. He had quite a collection of spruce plants, showing injuries due to improper planting, notably because the transplants were set too deep in the soil—often due to pit planting when the pit fills up with earth. When this is done, he has shown clearly that a new set of rootlets are found nearer the surface, the old root system decays and the result is a decayed butt.

THE TECHNIQUE OF PLANTING IN AUSTRIA

The basic principle of correct planting in Austria is to make the breadth and depth of the holes commensurate with the size of the plants; to see to it that the roots have plenty of room, so that they will not be cramped or crowded together; to make sure that the plants are set in the ground at the same relative depth they attained before transplanting, with roots in their natural direction and surrounded on all sides with loose earth. Dr. Reuss proceeds as follows: (1) With a mattock he skims off the upper layer of the soil, whether grass covered or not, on an area at least 2 by 2 feet; the good earth is chopped off to the right and the litter is put sideways to the left. (2) The rich layer of soil (humus) is chopped into small pieces by light strokes of the mattock, beginning on the side nearest to the workman and continuing on to the opposite side. (3) This earth is carefully removed with a mattock toward the right. (4) The hole for the plant is made deeper with the mattock as required by further strokes, and the new earth thrown out (usually already distinguishable by its color) is put next to it. In both cases, however, great care is taken that no earth is mixed with vegetable matter (moss, shreds of turf, leaves, etc.), as it acts injuriously in a very evident manner upon the plants' power of resistance during the dry season. (5) Above all, great care must be taken not to plant too deeply, for this means that the plants become diseased and in many cases even die off. The plants are set in such a way that the roots are covered over with earth from 7 to a maximum of 14 inches deep if the hole for the plant is covered up again to the level of the soil. (6) In order to satisfy the exigencies mentioned under point 5, the depth of the hole for every plant is examined again before the final planting takes place, and in case too shallow it is enlarged, or in case too deep filled in with humous soil made into a mound-shaped form, especially in the case of plants with flat roots, and reduced to the right size. (7) Finally, the plant is taken in the left hand and suspended over the plant hole and placed into such a position that all the roots fall into their right position and direction. Then he quickly covers the roots with soil with the right hand, which is free; first the humous earth and then the ordinary earth. At this point great care must be taken that (8) between the roots no hollows remain and (9) the plant hole is filled up to the level of the soil; therefore no hollows remain which later can be filled up with mud by rainfall and cause the injurious covering up of the root knods. Dr. Jugoviz demonstrated his method under the same conditions a week later at Bruck a. d. Mur. The variations from the former method are as follows: (1) The chopping of the soil into small pieces in making the hole for the plant is not done by the usual long-handled mattock, but with a more handy, short-handled hoe. (2) In order to keep within the limits of the right depth in planting the plants, a planting stick is used (a small, straight, wooden stick from 24 to 28 inches in length), which is laid straight across the hole to mark the level of the soil for the workmen and to offer a support for the hand in which he holds the plant, so that he is able to imbed the plant at the right depth. (3) After covering the roots of the plant with soil as far as the root knods, as was done formerly, both hands are used simultaneously to push the plant two to three inches into the ground in order to get a little space on both sides, and by moving the palms of the hands right and left to enlarge the space to such an extent that the fists can be closed in it. The earth is now pushed horizontally with the fists (simultaneously) on both sides against the roots of the plants. Immediately afterward the fists are withdrawn and the space remaining within the plant hole filled in with soil. Both spaces which have been filled up with earth are pressed down vertically with the fists and the remaining excavations are filled up with earth, but this time only loosely. By the fact that the earth has been made more compact around the roots the water can rise from the subsoil by capillary attraction and the roots receive a sufficient supply of water even when the dry season sets in. By the additional fact that the earth is left loose on the surface around the plant further capillary action results, and besides evaporation is interrupted, or at least lessened; consequently the freshness of the soil around the plant is assured, the more so as the uppermost looser layer of earth is rendered permeable to the dew. (4) The sod was cut out in two strips and placed at the down-hill side of the hole (slope here was about 8 per cent). The same operations were then gone through, omitting the mound. During a year when there is danger from May-bugs (cockchafers) the sod is placed directly on the soil so the insects will not find a resting place. Both Dr. Reuss and Dr. Jugoviz warned me against ordinary pit planting, especially with a shallow-rooted species, because of the danger of the formation of new surface roots and the consequent death and decay of the original root system.

The preparation of the holes for plants takes place as a rule in the spring immediately before the planting, especially in soils which are inclined to dry up, and even in wet soil in order to avoid the collection of water in the plant holes. It appears advisable in uncultivated, imperfectly prepared ground, also in soil of a binding nature, even if fresh, to prepare the holes for spring planting in the previous autumn, so that the soil taken out of the holes may be well aired during the winter. Where in such case it is necessary to water the holes, a part of the earth which has been dug out is immediately put back loosely into the plant hole. In one locality the planting spots are prepared in the fall, because labor is harder to secure in the spring and is more costly.

KARST PLANTING IN AUSTRIA

In the limestone mountains which traverse the Austrian Empire along the Adriatic in several chains from northwest to southeast one sees those evidences of erosion which are called "Karst phenomena" by physical geographers and geologists; they are unusually severe. These countries, to which also belong parts of Corinthia, Croatia, and Bosnia, as well as the whole of Görz, Istria, Dalmatia, and Herzegovina, are called in short "Karst countries." The presence of the great rocky deserts which extend here is not to be justified or explained either by geognostic or by climatic circumstances (which has now been fully proved), but are, unfortunately, the results of the destruction of forests in bygone times by fire, imprudent deforestation, and excessive grazing. For half a century the Austrian government has taken great pains in the reforestation of the Karst deserts in the interest of the public and, as is generally recognized, has achieved considerable success in this respect.

In this reforestation the most successful results have been obtained with the Austrian pine (*Pinus austriaca*), and especially with two-year-old plants. Yet its growth in the first few years is certainly so slow that after ten years of cultivation it scarcely reaches a height of 40 inches.

Only when a layer of humus has been formed by the fall of needles does the growth begin to increase. Three-year-old plants are only occasionally employed in localities which are protected against storms, for where the dreaded Karst storms reign the youngest tips of such older plants, thanks to the heaviness of their needles, are shaken to such an extent that a funnel is formed in the earth at their root neck and the plants dry up.

The Corsican pine (*Pinus laricia*) flourishes only in the lower southern part of the Karst and requires besides a better and deeper soil. The maritime pine is too sensitive to frost and the deep-rooted young plants are easily injured by uprooting. *Pinus halepensis* is very sensitive to transplantation.

Hofrat Petraschek gives the following figures as a result of the data collected by him in the Austrian and Hungarian Karst territories, and as the result of his own experiences in the cost of Karst reforestation in Bosnia-Herzegovina, where from 2,800 to 4,000, or an average of 3,400, plants per acre are planted out:

	New planting operations.	New planting operations, including necessary improvements.
	Dolls. per acre.	*Dolls. per acre.*
(1) Fencing the cultivated areas by walls as a protection against cattle. These walls are constructed of stones without mortar, with which the Karst is everywhere strewn; they are mostly 40–64 inches high, 24–44 broad at the ground, and 16–28 inches at the top	2.62	2.62
(2) Excavating the holes for plants (with the pick-axe) 12–16 inches deep and the same in diameter. A powerful man can make 300–400 of these holes in a working day of 11–12 hours	5.69	6.07
(3) Procuring the soil for planting from places nearest the planting area where there is rich soil	1.10	1.21
(4) Digging the plants at the nursery, packing and transport to the planting area (exclusive of railway transport)[19]	0.56	0.78
(5) Setting the plants in the holes; a woman can plant 200–300 in a working day of 9–11 hours	3.44	5.31
(6) Care of the plants ($0.33 per 1,000 plants)	1.13	1.58
(7) Costs of overseeing	1.44	1.44
(8) Costs of administration	0.74	0.74
	16.72	19.75

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[19] In view of the great public importance of the afforestation of the Karst, the railways undertake the transport of plants free of cost.

NURSERY PRACTICE

The school nursery at Bruck is progressive and consequently new methods are continually being tried out. The spruce is usually sown in drills, more rarely broadcasted, and is ordinarily transplanted into rows 6 inches apart, spaced 2 inches in the row. The transplanting is either in open trenches, with the Häcker apparatus, or in furrows made by the spade. The weeds are removed by hoeing and by the machine weeder ("Planet Junior"). The beds, 33⅓ feet long and 3⅓ feet wide, form one continuous transplant area of 111 square feet. Seedlings are protected from the sun by three methods: (1) By spruce or fir branches stuck into the soil bordering the beds (or laid upon the beds during germination), a crude but apparently practical method. (2) By an alder nurse crop. The alder plants are 8 to 10 inches apart and between every other row spruces are planted. Not only does the protection benefit the transplanted spruce, but it also (as Hofrat Petraschek contends) improves the quality of the soil. In another bed hemp plants (*Cannabis sativa,* Linn.) were being grown on the south side for protection—a miniature wind and sun break—which by cutting out the leaves can be kept quite compact. (3) The third protective method used was something like the lath frame used so extensively in American nurseries (Pl. I, Fig. 2). Here a network of wooden sticks, which can be rolled up like a mat, is used. The sticks, one-third of an inch in diameter and 3 feet long, are bound together, one-third of an inch apart, by soft zinc wire. In other words, the sun is intercepted on half the area, but it filters through more evenly than when laths are employed. It is also more readily handled, since it can be easily rolled up.

A SMALL LOCAL NURSERY

Dr. Jugovitz has another nursery in the school forest at an elevation of some 1,000 feet above the school. It is distinctly a small local nursery, answering the requirements for raising plants for use in the immediate neighborhood. It is situated on a protected north slope, but during the winter the seedlings are mossed between the drills in order to protect them against frost. They had also tried leaf litter, but preferred moss, which could be secured cheaply and which also was a protection against the fungus (*Herpotryclma nigra*), which in the Alps often destroys whole nurseries; mulching also prevented drying out and stopped weeds from coming in so thickly. The spruce is left two years in the seed bed and two years in the transplant bed in case four-year-old material must be raised. Otherwise the one-year-old seedlings are pricked out and then planted in the field when three years old. Half the time wild stock are used for conifers planting. Planting as well as sowing is only employed to supplement natural regeneration, which has failed in part or in whole. It is quite significant to find a small local forest nursery within a mile and a half of a large forest school planting station.

OTHER NURSERY PRACTICE

Another method of getting spruce for field planting was used at one nursery in the Wienerwald. Here the spruce was sown in drills, but the surplus seedlings were gradually (only a few first year) cut out, so that after three years the drills looked like transplant rows, with 23 to 25 seedlings in a row, 39 inches long. This method was considered cheaper than pricking out and produced sufficiently hardy stock for good field conditions. In a communal nursery near Wiener-Neustadt some of the beds were completely wire screened as a protection against birds, mice, and hail. The screens were 15 inches above the ground and resembled those used by the Forest Service, except that a larger area was under one screen—that is, about 20 by 20 feet. The pricking out (verschulung)[20] of one-year-old Austrian pine at this nursery cost about 12½ cents a thousand (in the United States this cost is usually from 50 cents to $1). The seedlings had roots 8 to 9 inches long and these were not root pruned. The Häcker pricking-out apparatus was used and the threading board was tipped with tin; the spacing and width of the beds was gauged by an iron frame. The openings, 10 to 11 inches deep for the plants which have been pricked out, were made with a big, heavy, long-tined rake. The crew consisted of two men and a small boy and girl; they transplanted some 7,000 a day.

FOREST RESEARCH INSTITUTE AT MARIABRUNN

As shown in the organization plan, the technical management (department IX) of the Ministry of Agriculture also takes a leading part in experimental forestry, for this is (as well as the agricultural experimental stations) a government institution. According to existing regulations, the chief of the experiment institute (which used to have its central offices in the building of the former forest school at Mariabrunn) is an executive officer of the Ministry of Agriculture; but the latter makes decisions in regard to experiments in conjunction with the chief of the experiment institute.

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[20] Hofrat Petraschek objects to the term "transplanting" and prefers "pricking out" in order to distinguish nursery transplanting from field transplanting.

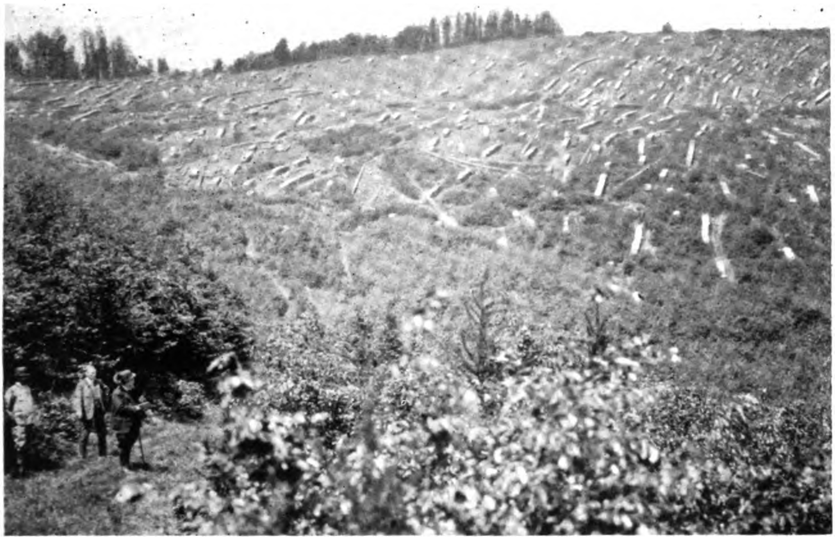

FIG. 1.—CLEAR CUTTING IN BEECH, FOLLOWED BY THE PLANTING OF LARCH AND SPRUCE. (WIENERWALD)

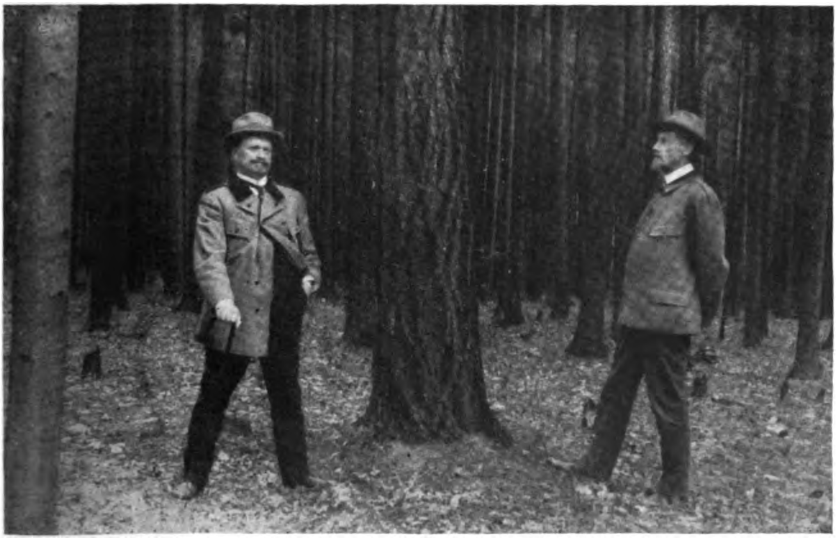

FIG. 2.– LARCH IN MIXTURE WITH SPRUCE AND AUSTRIAN PINE IN BARON HERTZFELD'S FOREST

PLATE V

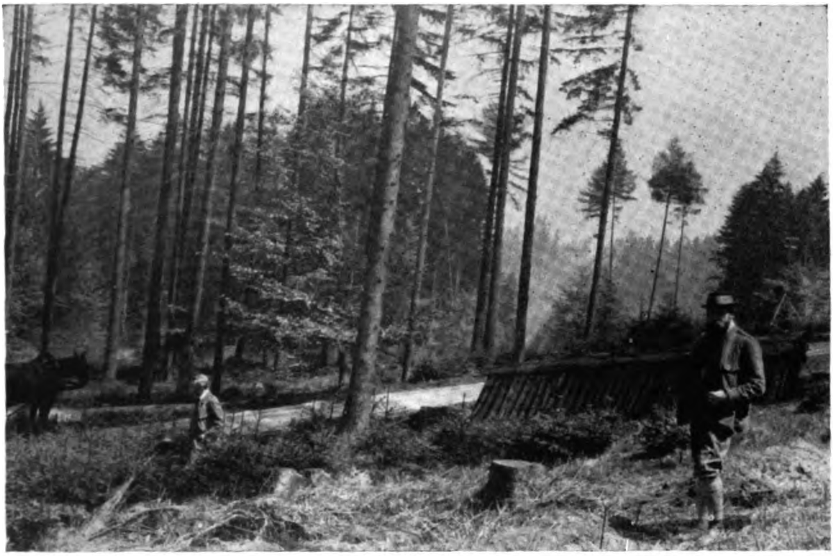

FIG. 1.—NATURAL SPRUCE REPRODUCTION IN TOWN FOREST OF BRUCK

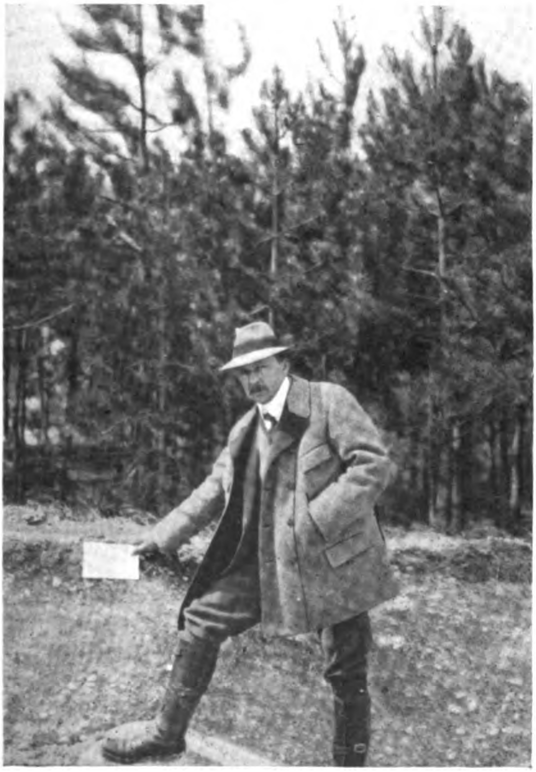

FIG. 2.—AUSTRIAN PINE OVER GRAVEL, ON THE "STEINFELDE"

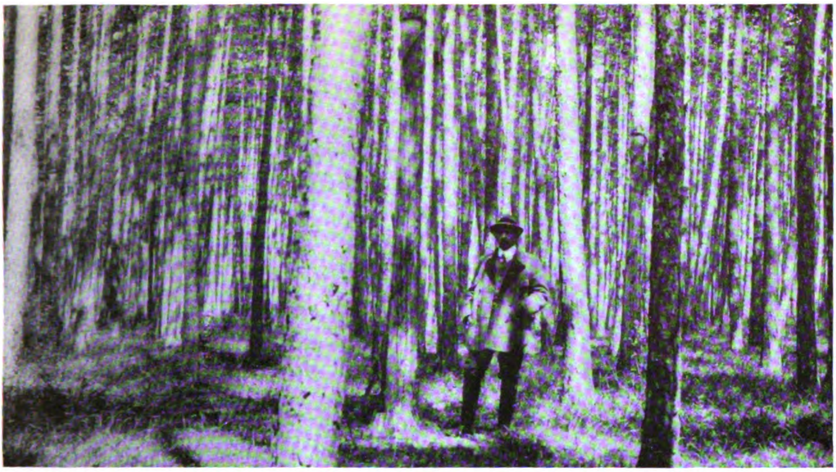

FIG. 1.—AUSTRIAN PINE 120 YEARS OLD, ON THE "STEINFELDE"

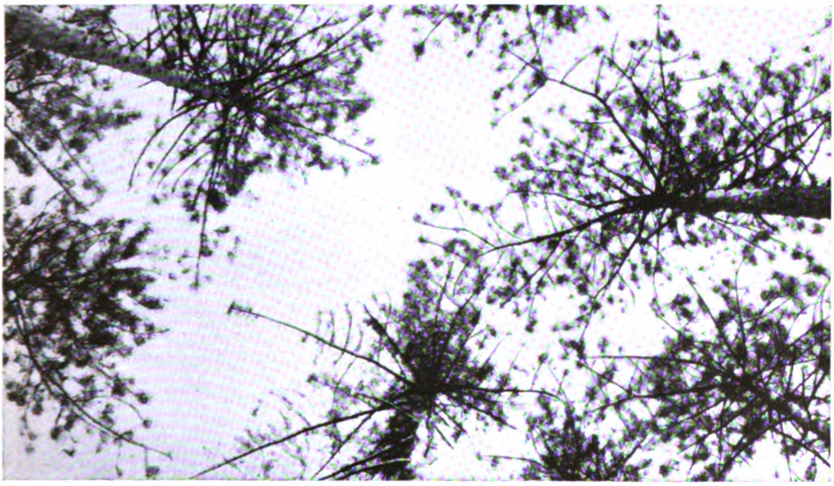

FIG. 2.—CROWN VIEW OF STAND SHOWN IN FIG. 1

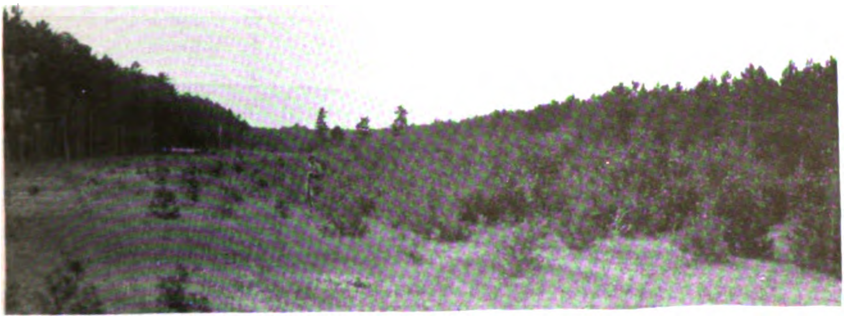

FIG. 3.—NATURAL REPRODUCTION OF AUSTRIAN PINE IN THE "STEINFELDE" ON A CLEAR-CUT STRIP

In order to kindle interest in the forest experiment station and to increase and to make sure of the participation by private forest owners and their officers in the experimental work (under the leadership and control of the forest experiment institution), land commissioners for forest experiments have been created in several parts of Austria.

Although for a long time there has existed a very liberal experiment program, elaborated by the forest experiment institution and sanctioned by the Ministry of Agriculture, still during our visit to the institution one of the government forest officials present made some minor criticism to the effect that those experiments which would have been of the greatest importance in the practice of forestry were not given sufficint prominence.

Hofrat Petraschek, who not only is well acquainted with experiments already in operation, and also with those in process of being put into practice, does not consider the aforementioned criticism justified.[21]

The assistant for plant physiology showed me the experiments attempted six years ago on selected seed, chiefly with silver fir. In other words, these experiments are meant to solve the important practical question whether the descendants of different individual trees of the *same* crop or of the *same* district take different form. Up till now the experiments have proved the truth of this. It has been plainly demonstrated that when the mother stock possesses a loose-spreading crown, few but strongly developed branches, and a long annual shoot, all these good qualities are passed on to its descendants. In the same manner compact, small crowns, with numerous weak branches, a short annual shoot, and the tendency to slow growth are inherited from the mother stock by descendants. If one wishes to grow a crop of silver fir for purposes of producing timber, then one must plant seeds from individual trees, with wide-spreading crowns, etc. As silver-fir trees from uplands or from northern districts possess compact small crowns, their seeds should not be used to sow in low-lying situations or intermediate districts. The descendants of silver-fir trees from southern Bohemia were almost twice as tall as the descendants of silver-fir trees from Scotland, western Norway, and Finland. What is stated here as regards the silver-fir tree has also been true with Austrian pine and Norway spruce.

The former assistant of plant physiology, Dr. Ciczlar, now professor of forestry at the "Upper School for Ground-culture" in Vienna, undertook extensive experiments upon the varieties of seeds of one and the same species of trees in different climates, which led to important results, subsequently confirmed by forest and other experimental institutions: *"To collect the seed for sowing in those districts where it is to be used, or if opportunity to do so is wanting, to take the seed from such localities whose climate mostly resembles the place where the seed is to be sown."*

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[21] Hofrat Petraschek has made experiments on the gradients of timberslides and the wear and tear caused by the sliding of the timber. See Vol. II of "Mitteilungen aus dem forstlichen Versuchswesen."

CONTROL AND EXECUTION OF THINNINGS

The staff from which the forest rangers are drawn is already trained on a practical basis at the forest rangers' school in the art of thinning. Until they have obtained the position of "foresters" they have ample opportunity to acquire experience in the art of thinning. Even after having obtained the position of "forester" after satisfactory service, they are nevertheless not allowed to undertake independent thinning operations. Such a thing *never* occurs in any case. Only the older, thoroughly reliable forest rangers are allowed to mark the poles and saplings to be thinned out. Moreover, before the cutting takes place it is controlled by the forest supervisor. No supervisor would omit this control, for he *alone* is responsible for all that occurs in his forest. If the forest rangers cannot be trained to mark the thinnings correctly, the supervisor would not receive any help from the rangers in a great many operations. But to what purpose should the government forest administration take so much care in training capable forest rangers? Of course, there must always be control over the preparatory work before it is actually carried out, and this is what happens. In the Prussian and Danish state forest administration service the forest rangers also mark thinnings. If this were otherwise, the forest administration districts would have to be much smaller and the expenses of administration thereby increased.

SEED EXTRACTION [22]

Through the courtesy of Mr. Julius Stainer, of the seed firm of Stainer & Sons, the operation of their seed plant at Wiener-Neustadt was explained. From the firm's standpoint it would have been preferable if the plant were entirely fireproof, since in its present condition it seemed quite inflammable. The arrangement of the heating plant and drying trays is quite simple. The fresh air comes from one side of the building through three air-tubes, which can be regulated in winter, and is conducted to three central heat chambers, which are connected with the three ovens directly opposite. After passing up through the drying trays, the saturated air escapes through three chimneys, 2.3 feet square. The drying trays are 2 inches deep by 20 inches wide and 5 feet long; the cones are not heaped on the trays, but instead are spread in single layers. There are 120 trays in each compartment (three compartments in plant), which is double; there are 15 tiers, four trays to the tier, and each tier is 4 inches apart. It is interesting to compare this commercial plant with the improved Prussian plant described by Mr. Recknagel in Forest Quarterly, Vol. X, No. 2, pages 229-234.

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[22] This chapter was not reviewed by Hofrat Petraschek, but by Mr. Julius Stainer, the active manager of the well known seed firm of Stainer & Sons. All Mr. Stainer's cost figures are based on the ratio of 5 crowns to one dollar, which is only an approximation.

AUSTRIAN PINE

For ripe Austrian pine cones it takes 24 hours' drying at a temperature of 35° C. (F. 95°); for green cones it takes 36 to 80 hours at a temperature of 45° C. (F. 113°). After drying, the pine cones and seed are sent through (by gravity and by rotation) a cylinder of wire netting, with 0.4-inch mesh; the cylinder is 3.28 feet in diameter and 19.68 feet long and is inclined 1 in 20, so the cones will naturally roll out as it revolves. As explained under "storage," the seed is not cleaned until just before shipment. Mr. Stainer believes (as a result of private experiments) that the best method of separating the wings is to use the primitive peasant grain-threshing system, namely, a leather-covered flail operated by hand. In this plant the seed was spread on a *board* floor, since it would be injured if threshed on cement. The workmen may as a precaution have their shoes bound with cloth to prevent injury to the seed when threshing, but this does not appear to be essential. The three ovens described have, under average conditions, a capacity of 750 pounds of seed per 24 hours. For every 220 pounds of Austrian pine cones (cost, $1.05 to $4.20; average, $2.10) delivered, Mr. Stainer gets 6.6 to 7.7 pounds of clean seed, running on an average 60,000 seed to 2.2 pounds, with an average germination of 80 per cent.

LARCH

The larch cones must be treated differently. For separation they are placed in an iron drum and rolled for 8 hours at a rate of 45 revolutions per minute. The drum is 5.9 feet long and 4.92 feet in diameter. The inside surface is roughened with little strips perhaps one-fifth of an inch long and one-fifteenth of an inch high. There are openings about 15/100 of an inch in diameter and 2 inches apart to let the seed and debris fall out. This is automatically carried away (grain-carrier system) and the larger debris sorted out. The seed is cleaned by a fanning mill just before shipments. For every 220 pounds of larch cones (cost on average

$7) the yield is 17.6 pounds of clean seed, with 40 to 50 per cent germination.

NORWAY SPRUCE [23]

The treatment is almost the same as with the Austrian pine except that care must be taken that the temperature of the seed kilns does not rise above 35° C. (F. 95°). One of the principal requirements is that there should be a large supply of fresh air in the seed-kiln room. The threshing of the seeds formerly took place, so that the seeds were very moist before threshing. This moisture caused the seed to swell and to detach itself from the husk; subsequently a slight rethreshing of the seed sufficed, coupled with the cleansing by the fanning mill.

This sort of threshing is still practised, but it is not considered rational, as the seed already begins to germinate through the effects of the moisture and the consequent swelling, although this is afterward stopped when the seed is not at once sown, but instead is stored for many weeks before being used. Such moistened seeds, therefore, quickly lose their germinating powers, and if stored in a sack they often lose it completely.

Therefore, the Norway spruce seed is threshed in a dry condition by means of a revolving brush, and in this manner the disadvantages described above are avoided.

Two hundred and twenty pounds of cones cost $1 to $1.40 in a good year; in a bad year, however, as last year (1911), $3.60 to $4, and yield on an average 8.8 pounds of seed; somewhat more with a good crop, but in a bad year it might fall as low as 4.4.

SILVER FIR[23]

The process of cleaning is similar to that employed for Austrian pine; the same temperature and same length of time, only the seed must be treated very carefully because its shell is very thin and can be easily broken. The seed suffers a great deal if threshed after being moistened, and therefore it is threshed almost exclusively with the brush machine.

Two hundred and twenty pounds of silver fir, which cost from $1.20 to $2.20, and even as high as $2.80, produce 2.75 to 3.85 pounds of seed. The price and yield depend always on the result of the crop, as the cones contain more seed in a good year than they contain in a poor seed year, when the seed is expensive. The high price of cones is caused by the scarcity of seed, when it is difficult to induce workmen to undertake gathering.

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[23] These data were prepared by Mr. Julius Stainer.

A SMALL EXTRACTION PLANT AT WIENER-NEUSTADT

At a local ranger station in the communal forest of Wiener-Neustadt there was a small Austrian pine seed extraction plant which might be adapted with modifications to use on private estates or Federal forests in the United States. It is illustrated in Plate II, Fig. 1. The seed-house (also used for tools) has bins which look like coal-bins, with supply doors (12 by 12 inches) above the drying trays; these trays are 50 by 100 inches and 11 inches deep, outside measure. Inside each tray there is a wooden screen resting on props. These screens are 7¼ inches below the surface of the trays and are simply triangular wooden slats 1½ by 1½ by 1½ inches, laid one-quarter of an inch apart and cleated together. The screens lift out when the cones have been opened by the sun, so the seed can be gathered from the bottom of the tray. The cones are spread one or two thick and are frequently stirred during hot, dry weather.

SEED SHIPMENT

The Japanese government has ordered seed from Stainer & Company and the percentage of species ordered is interesting: Austrian pine, 70 per cent; larch, 20 per cent (none of the Siberian variety allowed); spruce and Scotch pine, each 5 per cent. Of course, the figures are approximate. This seed is shipped in wooden boxes lined with tin. In the future it is believed American purchasers should insist on this method of packing, which costs but little more.

THE STORAGE OF SEED

When it is considered that Stainer & Company handle a million pounds of coniferous seed each year, and that much of it must be stored over the winter, the seed storage is a vital economic problem. A loss of 5 per cent germinative vigor would mean a theoretical loss of 50,000 pounds if a million pounds were stored; at 50 cents a pound this loss would amount to $25,000. In storing large quantities of seed they use a cement room (second story), protected against light, heat, and cold with double shutters. The secret of successful storage has been found by experiment to be storage (of pine seed) with the wings on, since the wings are good non-conductors of heat and cold. The seed is tramped together so no air can circulate, and of course the seed is thoroughly dry before storage. Mr. Julius Stainer states that if this seed were stored with the wings on, the loss would be 5 to 7 per cent in germination per cent. The best storage temperatures would in theory be between —15° C. (F. 5°) and + 1° C. (F. 33.8°), but to maintain such a temperature continually would cost altogether too much to be commercially feasible. Even sealed glass jars are considered impracticable for the small quantities of rare tree seeds, which are now stored in sacks.

PERMANENT IMPROVEMENTS

A great deal of care is spent in laying out roads, which cost 63 cents per 3.28 feet and up; but there were many old trails which were apparently not laid out,on any grade. Judging from these paths, it certainly behooves any forest service to see that roads and trails have the proper alignment at the start before an expensive roadbed is developed. Changes later on will be exceedingly expensive. Ranger house and supervisor offices are permanently constructed of stone and cement. A house for forest workmen costs about $600; a ranger station, $3,000, and a supervisor's headquarters (office and living quarters) $8,000. Plate II, Fig. 2, shows a local supervisor's quarters. It was situated near the center of the forest, by the way, and not to suit his personal convenience by being in or near a town. Since a state does not carry fire insurance on its buildings, it is all the more reason why permanent fireproof construction should be insisted upon.

An excellent example of a "ranger station" was found on the town forest (used for instruction purposes by the local forest school at Bruck a. m.). The house and adjoining stables (Swiss chalet style) had a splendid stone foundation, with suitable drainage. The office was on the ground floor, with a kitchen and bed-room; a second story contained three bed-rooms. The administrative quarters were nicely paneled and plastered and were furnished with chairs, tables, desk, and cupboard; the walls with trophies. Other features were vegetable garden and yard, running water, milk-room, feed-room, stable, with gravity drainage, upper and lower porch. The quarters cost $3,780. A hut near by for the "woods workers" cost $105.

THE WIENERWALD STATISTICS

The famous Wienerwald, which stops at the confines of the northeast Alps, is in greater part owned by the state; it comprises a total of 70,411 acres, of which 66,705 acres are forest; 2,661 acres are fields, meadows, and gardens; 378 acres are alpine pasturage; 200 acres are other productive land, and 467 acres are waste land.

In view of the fact that this forest area exercises an incontestable influence on the climate of the district, within which lies the town of Vienna, and affects the stability and amount of its water supply, and, furthermore, because of its value as a pleasure resort for the Viennese, its administration is thoroughly conservative; therefore, although it contains a large quantity of old trees fit for timber, the annual yield is only 4,809,000 cubic feet in principal yield and 663,900 cubic feet in the intermediate yield, a total of only 5,472,900 cubic feet; 67 per cent of this is from broad-leaved trees and 33 per cent from conifers.

The revenue is as follows:

Receipts	**$289,976**	**$289,976**
Expenditure	**223,436**	**........**
Cost of administration	**8,591**	**232,027**
Yearly receipt	**(net)**	**$57,949**

or $0.828 per acre of productive area. This revenue would, of course, be considerably increased under a less strictly conservative administration.

CONVERSION PROBLEM IN THE WIENERWALD

As already mentioned, the beech predominates in two groups. The government forest administration, however, has intended for many years to lower the predominance of the beech in these groups. The chief motive is the small sale value of the beech wood as fuel. When the import of coal to Vienna became easy and cheap, the demand for hardwood for fuel decreased steadily. The prices for beech timber indeed show a tendency to rise, but the percentage of saw logs in beech is far too small to produce a financial profit that would justify the further maintenance of its predominancy. But what absolutely settles the question of changing the beech crops is the fact that, because small-sized wood has no value at all, heavy and early thinnings cannot be undertaken in young stands. Therefore it is impossible to raise beech which yields saw logs in short rotations. In place of the beech the oak is now chiefly raised in lower situations and on the better soil, and in all the remaining localities mixed crops, in which the beech on account of its excellent qualities of improving the soil is certainly granted a place, but in which pine and spruce must predominate.

The oak *never* grows alone, but is always mixed in large groups or clusters of trees. The raising of these groups or clusters takes place, so that the remaining beech crowns correspond to a crop of four-tenths at a maximum. Underplanting takes place under the oak, mostly by sowing in broad strips. The acorns are sown liberally because oak only grows well in a dense stand. After five years the leaf canopy of beeches, which have been held over, are removed.

The transformation of pure beech stands into mixed crops of conifers with beech takes place as a rule in as small felling as possible by the clear cutting of the beeches and subsequent replanting of the cleared surface chiefly with spruce, pine, fir, and larch. To get the admixture of the beech no special pains are taken, since in the Wienerwald beech undergrowth is rarely ever lacking. Then, when the beech stands are already naturally mixed with the pine, as in many parts of the third group of the Wienerwald, it goes without saying that they work so as to regenerate the pine, and the regular shelterwood system is used. In order to promote the natural regeneration of the pine at the beginning of a seed year, care is taken to wound the soil; large fail-places are planted out with larch, smaller ones with white pine. Douglas fir and other foreign conifers are also being tried out.

OTHER WIENERWALD NOTES

In one district the rotation for the beech was 100 years and the reproduction period 10 to 15; the stumps were 8 to 10 inches high (top side measurement) and the brush left in windrows or small irregular piles. The prices realized for the straight, 12 to 22 feet, beech logs in the woods after felling are as follows: Eight to 12 inches (middle diameter), $2.94 per cubic meter; 12 to 20 inches, $3.70 per cubic meter; over 20 inches, $3.99. This corresponds roughly to $25 per thousand board feet of skidded logs as scaled by the Scribner Rule, decimal C. In this division there was a little erosion along a few of the log trails. In another compartment a heather-covered hill, with a southerly exposure, had been planted to spruce, larch in mixture with natural beech, and a little white fir and birch. The birch was "whipping" the conifers and will be gradually cut out. The former stand was beech, with fir and birch. The plants are usually spaced 4.26 feet and four-year fir, three-year spruce, two-year larch, and one-year oak are used. In addition some ash, elm, and hornbeam have been used in filling blanks. A week later we visited another part of the forest.[25]

Plate III, Fig. 2, shows a 60-year stand of white fir and beech directly after the first thinning. Here lack of roads prevented an earlier cut because the stand was isolated and the prices low. About 25 per cent of the total volume was removed—seven-tenths of the cut in beech and three-tenths silver fir the favored species. The few Austrian pine and larch in mixture, which were doing remarkably well, were not cut. The brush was left scattered on the ground because it had no sale value. After the rotation of 100 years is completed the stand will be clear cut and planted to conifers. In this (limy clay, or thonig-mergeligen) soil some old

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[25] Our tours were made in the official limousine, which covered some 20 to 25 miles an hour over these forest roads. The chauffeur knew the country thoroughly, and at the end of a trip we always found the car to whirl us back to Vienna.

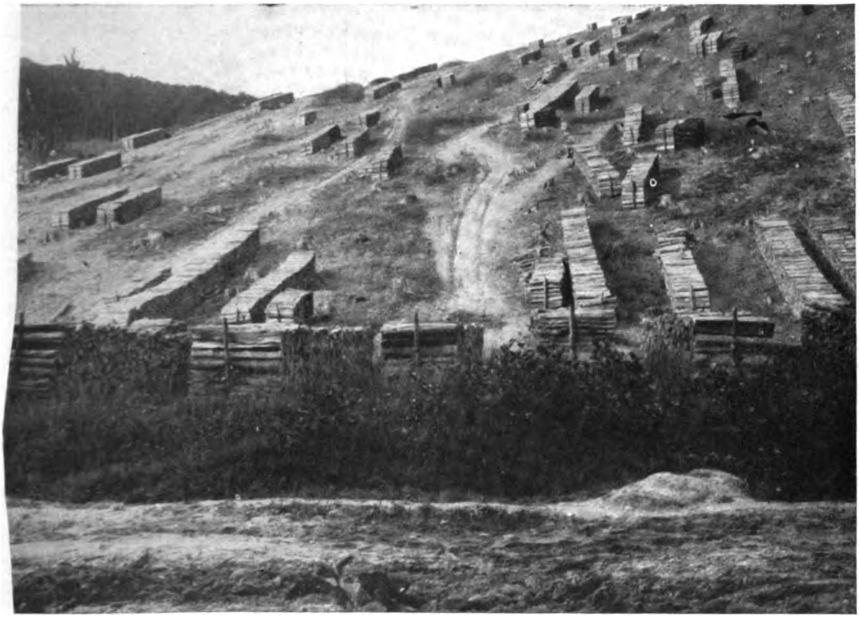


FIG. 1.—AN EXTENSIVE CUTTING APPROXIMATELY 150 YARDS WIDE

Some of the oak logs and all cordwood are still on the ground. The stand was chiefly beech 120 years old and produced from 300 to 350 cubic meters per hectare, of which 82 per cent was cordwood. The smaller wood up to 3 inches in diameter in the round is worth, piled by wood road, 4 crowns per cubic meter. Cost of cutting, 1.2. One man will cut from 1 to 3 cubic meters per day. The larger wood is worth from 6 to 6.50 crowns. Cost of cutting and bringing to the road, 1.3 crowns per meter. Cost of transportation to Vienna, 5 crowns. Usually 15 to 20 per cent of the best beech is used for sawing and other similar purposes and brings from 12 to 15 crowns per cubic meter in the woods. The soft woods—larch, spruce, and pine—bring from 20 to 25 crowns per cubic meter. The best fir brings 15 to 18 crowns. (Wienerwald.) Photograph by James W. Toumey.

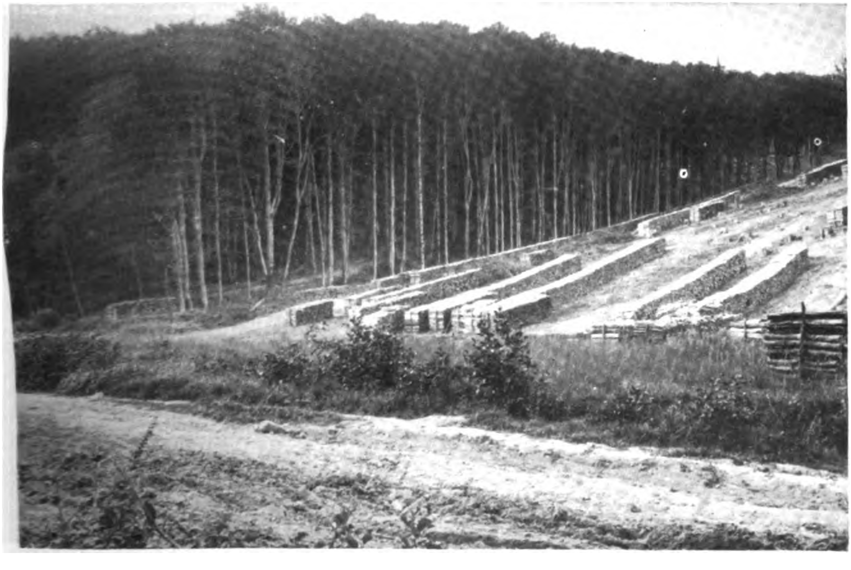


FIG. 2.—THE SAME STAND, WITH OLD WOODS STILL UNCUT AT THE LEFT. (WIENERWALD)

Photograph by James W. Toumey

PLATE VIII

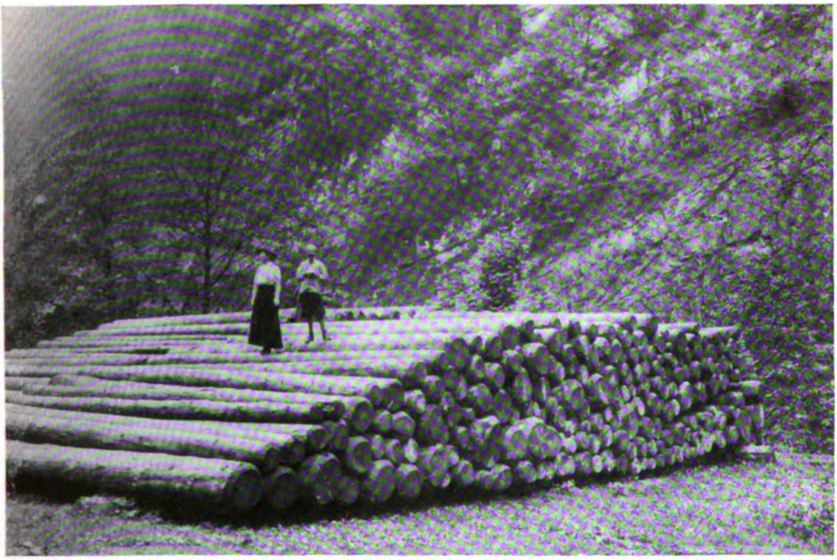


FIG. 1.—A SMALL WOODYARD BY THE RIVER

The wood is all spruce of best quality. Near Heiflau, Austria. Photograph by James W. Toumey

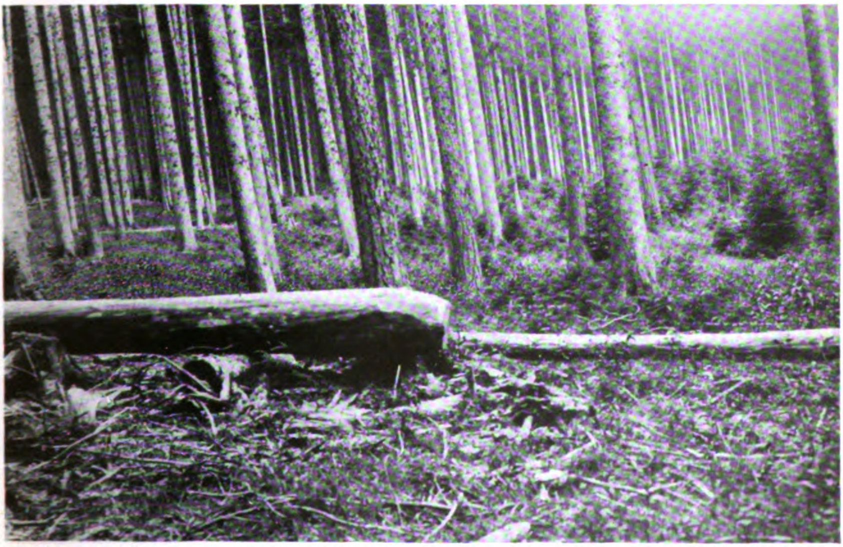


FIG. 2.—ONE OF THE BEST STANDS OF SPRUCE IN AUSTRIA

Few Scotch pines and silver firs in mixture. Timber is worth at foot of Reisweg from 15 to 24 crowns per cubic meter. Stand 100 to 130 years old. Reproduction excellent, as a result of Wagner's method of border cuttings. Photograph by James W. Toumey.

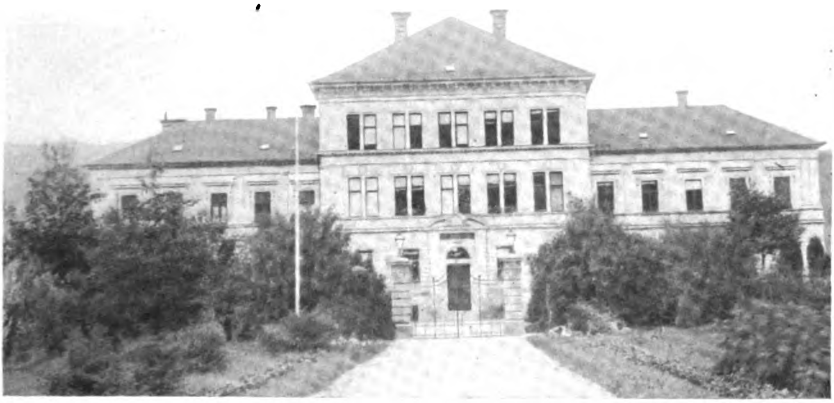


FIG. 1.—THE FOREST ACADEMY AT BRUCK-AM-MÜR

A secondary forest school. Photograph by James W. Toumey

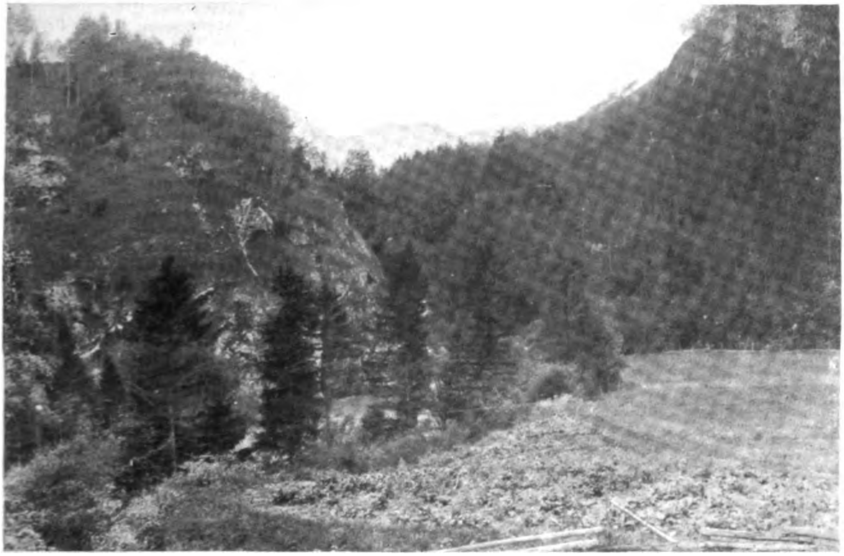


FIG. 2.—VIEW TYPICAL OF THE COUNTRY IN STEINMARK AND WILDALPEN

It is practically all forested. The distant slopes show various cuttings. Photograph by James W. Toumey

hauling roads had eroded 12 to 15 feet deep and a second road 6 to 9 feet. This was due to the steep grades. Recently a road on a correct grade has been built at a cost of $0.20 a foot. A thinning in pure beech was directly the opposite from the French method of "eclaircie par le haut" because merely the suppressed saplings had been removed from a stand of poles. Plate IV, Fig. 1, gives a clear idea of the present method of clear cutting followed by planting; in the foreground the old method of natural regeneration of beech is shown. Where in the natural beech regeneration spruce and larches had been planted singly, there was evident need of cutting back the beech, but this operation, it was explained, would at present be too costly. Of all the planting the larch seems to be doing better than the other spécies, but even the larch has been badly damaged by the deer, which have become a real nuisance.

The forest administration shows a wish to reduce the stock of game, which is made difficult by the lessees of the shooting, and as these are aristocrats, mostly very influential men politically, they obtain from the government the promise that the stock of game should remain undiminished. During the rigors of the winter these lessees go the length of having the game (stags) fed at their own expense. One block of the forest is visited during summer on Sundays by 40,000 to 70,000 people, so its importance as a playground for the people of Vienna can be fully appreciated.

The larch impressed me as thriving excellently in mixture with beech. Hofrat Petraschek assured me that the custom followed in the Wienerwald of putting the larches, in the form of good sturdy plants, between the upgrowing thickets of beech in order to improve them is possible because of the good soil of the Wienerwald, which increases the rapidity of their height growth when in mixture with the beech—even to an advanced age. But in keeping with the needs of both species of trees, Hofrat Petraschek would consider it better if the larch could be raised first in pure crops, and then after 20 to 30 years only be underplanted with beech.

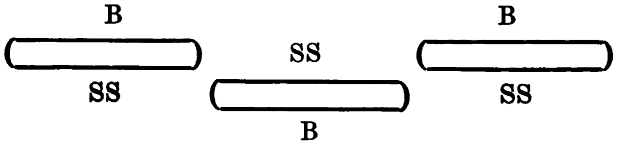
The larch flourishes also in mixture with spruce and pine, provided, however, as Hofrat Petraschek told me, that the larch be accorded a very considerable advantage as to age and, as far as possible, be mixed in groups. For, as Hofrat Petraschek further contends, if the larch were mixed evenly with the spruce when first planted it would be topped by the latter, owing to its height growth, continuing tto a greater age. If one wishes to preserve the larch among the pine for a long period of time it must be able (owing to its great demand for light) to overtop the crown of the pine.

A very fine mixed stand of spruce, pine, and larch in Baron Hertzfeld's forest (near Mährisch Weisskirchen), as well as the mixed stand of beech, pine, and larch near St. Corona, in the Wienerwald, were very instructive.

Larch seems to reproduce easily; in one place where some spruce-ball plants had been removed from a small local forest nursery there was complete reproduction of larch. Quite a little windfall of spruce and fir had occurred in one locality, although a severance cutting had been made some 59 feet wide 15 years ago.

THE BRUCK FOREST

The town of Bruck a. m. owns a forest of some 3,706 acres, of which 1,038 acres are under the direction of Mr. Jugovitz, the head of the local forest school. The net return is about $3.54 per acre per year. The chief species are spruce, beech, larch, and the rotation 80 to 100 years. The forest lies at an elevation of 1,500 to 5,000 feet. The chief silvicultural problem is the natural regeneration of spruce, supplemented by planting and sowing. The regeneration of larch is entirely by natural means. The usual form of cutting where the spruce has not already come in naturally is in strips 115 feet wide;[26] here the larch, one or two to the acre, are held over for seed or for increased diameter growth. These larch bring by occasional sales just double the price per unit the larch bring when cut in the ordinary course of felling. The difficulty of securing spruce reproduction unaided is well known and here it is no exception. In some places it is necessary to cut the weeds and brambles so as to make a good germinating bed. Seed spots about 6 feet apart and 2 feet square can be made (for the fail-places alone) at some $0.26 per acre. This seems incredibly low, but Mr. Jugovitz vouches for the figure, but emphasizes that this figure is meant for the entire naturally regenerated surface. Reduced to an average per acre artificially worked it totals $0.74 per acre. A mixture of beech is secured by seed spots, 7 feet long and 2 feet wide, sowed with a good handful of nuts. In a clear-cut strip planted to spruce (spaced about 4 by 4 feet) there were beech-seed spots spaced as follows:



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[26] One gains as a rule considerably in (natural) regeneration by strip-felling, if the felling areas open to the north, or northeast and west, as recommended by Dr. Wagner.

The thick growth of raspberries that immediately come in serve to divert the attention of the deer and is a good protection against sun and frost after the removal of old trees. Taken as a whole, the spruce comes in naturally on 20 to 25 per cent of the entire forest and is, therefore, supplemented artificially on some three-quarters. The total cost of this artificial regeneration is $2.50 to $4.97 per acre. Some of the former cuttings were poorly laid out with regard to the direction of fellings and it is feared considerable windfall may result during unusual storms.

THE AUSTRIAN PINE ON THE "STEINFELDE"

Any one who doubts the ability of the Austrian pine to grow on a poor-quality soil should visit the town forest of Wiener-Neustadt, on the so-called "Steinfeld," that forms the southwest part of the 860 spare miles of the great Wiener basin. The soil of the "Steinfeld" suffers from great dryness in spite of a sufficient rainfall, because it consists, in the first place, of rough, permeable limestone waste, with very little clay in mixture, and in the second place because the subterranean water lies at such a depth it cannot reach the upper strata. In order to make this poor soil more productive, it has been afforested with Austrian pine (Pl. V, Fig. 2). This afforestation dates back a long time, and, according to Hofrat Petraschek, it is said to have been secured by means of broadcast sowing after first loosening the soil by the cultivation of annuals. At the present time the afforestation is by means of both sowing and planting. The forests of the "Steinfeld," especially those belonging to the town of Wiener-Neustadt, are in many respects models of intensive management. The lowest branches of the young trees are used for fuel, and thinning is begun early. Furthermore, the trees are tapped for resin several years before the final cutting. It was a disappointment to see that not the "cup and gutter" system, but the superannuated "box" system, was used. Hofrat Petraschek explained to me that as regards Austrian pine there cannot be any question of a disadvantageous change in the quality of the timber through tapping for resin, considering that with this pine the amount of resin is increased by the tapping so much so that the wood entirely saturated by resin resists decay the longer, and on that account has a high value for building purposes as well as for fuel. The tapping privilege is rented at an average rate of 6 2/3 cents per tree per year. No trees under 9.84 inches are tapped, and on account of the poor soil the trees are only scarred on one side; the incision is one-eighth to one-sixteenth of an inch deep. The average yield is 6 pounds per stem per year, worth at present $0.03 per pound, besides the sale of timber ($2.10 per cubic meter), cordwood ($0.84 per "rundmeter," or about $7.35 per cord of 128 cubic feet).

Moreover, the litter—that is to say, the fallen needles—are sold to peasants owning the surrounding land, who must collect it themselves; only light wooden rakes are allowed to be used. The litter, however, of the entire forest area is not sold, but only on partial areas in rotation, which remain therefore fallow for three or five years. Permission to gather the cones is granted gratis upon application for a permit. The trees, however, may not be climbed, but the cones can be shaken down by means of long poles, to the ends of which are fastened sharp hook-shaped irons.

During a good seed year they get 20 to 22 bushels per acre from an Austrian pine stand 75 to 80 years old, namely, at its full producing capacity.

Plate VI, Figs. 1 and 2, show a stand (stem and crown view) 120 years old. To give a definite idea of the yield of Austrian pine under known conditions (top soil here was 8 inches over gravel), a square sample plot (one-quarter of an acre) was carefully calipered. The per acre figures are:

D. B. H.	No. of trees
6	148
8	208
10	112
12	4
Total	472

The average height was between 54 and 56 feet, and on account of the small taper it is certain the acre would yield at least 450 telegraph poles, or, roughly, 16,500 board feet, allowing 35 board feet for the average tree of 8 inches, which would surely cut a 16-foot log 6 inches, 16-foot log 5 inches, and 16-foot log 4 inches. In these stands the first thinning is made at 35 to 40 years and then every five or six years. The forest of 2,328 acres has a net yield of about $4,200 a year, or almost $2 an acre, from land which in America would be undoubtedly termed "waste land."

In this forest the Forest Experiment Institute of Mariabrunn has already undertaken (commencing nearly a decade ago) various experiments in forestry. In the first place experiments in thinning; in addition it undertook experiments to determine the influence of various repeated removals of the needle-litter upon the increment of the crops, and besides studies as to how the amount of needle-litter is affected by the various rotations for the collecting of the needle-litter. Then, too, experiments are being carried out to see how irrigation affects plantations and mature stands. Naturally, many years more of active experiments are still required before unimpeachable results can be secured.

All the experiment plots were well marked with chiseled stone corners and ditch boundary lines. Each experiment plot was isolated by a strip (treated by the same method) 12 feet wide.

It is hoped that some American forester will find time to make a more thorough study and report of Austrian methods, especially on private estates, because there is much to be gathered that can be directly or indirectly applied in the United States.

WHAT SHOULD BE DONE WITH THE CHESTNUT STANDS IN SOUTHERN NEW ENGLAND

BY J. W. TOUMEY

Delivered before the Society November, 1913

Throughout most parts of southern New England the chestnut has long been considered the most important, from the economic standpoint, of all the indigenous hardwoods. Its easy reproduction and rapid growth make it exceedingly productive. The high technical qualities of the wood give it an established market not only for sawing timber, but in small sizes for poles, ties, and posts.

Heretofore it has been the usual practice to clear cut chestnut stands in southern New England, depending upon sprout reproduction for the succeeding crop. The sprouting capacity of chestnut is such that this method of regeneration has served to keep the hardwood forests of southern New England in a fair state of production where chestnut is the dominant species. This is particularly true where fire has been kept out, even where no attention has been given to thinnings in order to stimulate growth in the crop trees.

The advent of the chestnut blight into practically all localities in New England where chestnut grows has not only stimulated the cutting of chestnut stands, but has also produced a discouraging outlook as to the future of this species in New England. After the infested timber is cut the sprouts arising from the diseased stumps are almost invariably destroyed by the blight within a period of two or three years.

Recent investigations conducted by the United States Department of Agriculture indicate that the parasite causing the chestnut blight was introduced into this country from China, and that it is a serious menace to the culture of chestnut in that country. The futile attempt at checking the spread of the disease in this country and its present appearance in nearly all regions where chestnut grows give little hope for the future as regards the profitable production of chestnut as a timber crop in this country, at least for some years to come. In the opinion of the writer, the hardwood forests of southern New England in which chestnut is the dominant tree should be immediately taken in hand and converted into hardwood stands of other species or into softwood stands of pine or spruce. The problem of making this conversion at a cost that will warrant the undertaking is a very important one. In localities where there is a market for wood of small size, wood for fuel, etc., the problem is comparatively simple, but becomes more difficult where economic conditions do not warrant the utilization of small and inferior material.

So far as known to the writer, but few attempts have been made as yet to transform our diseased chestnut forests into stands of softwoods or of other hardwoods. Where seeding and planting have been dne, it has usually been on burned areas or open fields, with no immediate prospect of natural regeneration of any sort.

Thirteen years ago the Yale Forest School began to transform certain mixed hardwood stands near New Haven, Connecticut, in which chestnut was the most abundant and important species, into coniferous forests. It is believed that the results obtained are of considerable value as relates to the success likely to be attained and the costs involved in converting our present stands of diseased chestnut into coniferous forests.

In the winter of 1904 the area was clear cut. The stand consisted of mixed hardwoods, with chestnut the most abundant species. The stand was approximately 65 years old and was converted into lumber, poles, ties, and cordwood, with practically complete utilization. In the spring of 1905 the area was planted with two-year-old white-pine seedlings. At the time of planting the area was practically clear of grass and other growth. Over a portion of the tract the spacing was 4 by 4 feet and over the remainder 6 by 6 feet. The trees are now from 2 to 8 feet tall and the density of the stand varies from 800 to 1,400 trees per acre. Intermixed with the pines are numerous oaks and other hardwood seedlings and many sprouts. Three cleanings have already been made in this stand in order to free the pines from the overtopping sprouts. It is believed, however, that two cleanings—one made at the end of the third year and the other at the end of the fifth year—would suffice to bring through practically all the pine. Without these cleanings, however, the pine is suppressed and killed by the rapidly growing sprouts. From the results obtained in this plantation, it appears that a spacing of 6 by 6 feet is sufficiently close. It is possible that a wider spacing—namely, 8 by 8 feet—would suffice to form a satisfactory stand where a hardwood forest has been removed immediately preceding the planting, as the spaces between the pines are largely occupied by sprouts and seedling hardwoods, which are removed in the cleanings only in so far as they overtop and interfere with the growth of the pine.

At the present cost of labor in southern New England and the present cost of planting material, the expense involved in converting a diseased chestnut forest into one of white pine by clear cutting the old stand and planting depends somewhat upon the completeness of the utilization of the old stand. Where complete utilization is possible and where the limbs and stems down to 2 inches in diameter can be worked into fuel, no expense is necessary in the preparation of the site for planting after the old crop is removed. The brush, if well scattered, will not interfere with the planting.

Small stock—namely, two-year-old seedlings—can be used in planting such sites without excessive loss, and, as a rule, should be used in preference to the larger and more costly transplants. Where seedling stock is used, however, it should not be grown in crowded seed beds. The stand in the seed bed should not exceed from 40 to 65 plants per square foot during the second year's growth. Although seedlings grown in dense stands, 100 to 200 per square foot, may usually be transferred to the transplant bed with safety, they are not suitable for field planting. When purchased in large quantities, two-year-old white-pine seedlings suitable for planting on recently felled areas in southern New England cost approximately $2.25 per thousand. When grown from seed by the planter, they can be produced in large quantities at considerably less.

Sites from which a merchantable stand of timber has been recently cleared are usually comparatively free from grass and other herbaceous growth and the soil is loose and friable. The actual operation of setting out the trees is much less expensive on such sites than on open areas, where there is more or less growth of grass or other vegetation, where the soil is compact and less retentive of moisture, and where transplant stock must be used. Under favorable conditions an experienced workman can set from 600 to 900 plants per day of 10 hours on sites from which a merchantable stand of timber has been recently removed.

The cost of the two cleanings necessary to remove the vegetation overtopping the pines during the first five years' growth depends upon the character of the stand removed and the time when felled. Chestnut sprouts grow with great rapidity, and if not diseased rapidly overtop the pine in their early growth. It is advisable, therefore, to clear cut the old stand in late summer, so as to reduce the vigor of sprout reproduction, and plant the following spring. Where the two cleanings are confined to liberating the overtopped pines the cost is approximately $3 per acre. In cases, therefore, where the closeness of the utilization makes a preliminary treatment of the site unnecessary, the total cost per acre in changing over a hardwood stand to pine at a spacing of 6 by 6 feet is approximately as follows:[1]

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[1] The cost figures given in this article for planting, after clear cutting, and for underplanting are for operations on a fairly large scale with efficient and experienced labor and where the loss is not sufficient to necessitate underplanting. Where the operation is on a small scale, with inefficient or inexperienced labor, and where the stock is poor, or where the conditions following planting are adverse, the cost of successful regeneration may be two or three times the figures herein given.

Planting stock (including transportation)	$3.00
Planting (including supervision)	4.00
Cleanings (liberation thinnings)	3.00
Total	$10.00

At a spacing of 8 by 8 feet the cost of stock and planting is reduced nearly half.

In the winter of 1901 a damage cutting was made in a mixed hardwood stand. The stand was from 50 to 60 years of age and its density was reduced by the damage cutting to approximately 0.5. In the spring of 1903 the area was underplanted with two-year-old white-pine seedlings. The overwood was nearly all removed in 1911 and 1912. At present the pines are thrifty, in excellent condition, and vary in number from 300 to 700 per acre. They have a maximum height of 12 feet. The pine is believed to be sufficiently dense to form a full stand, with the seedling hardwoods intermixed with them, which may, if desirable, be removed later in the early thinnings. It is believed that further cleanings (liberation cuttings) will not be necessary in order to keep the pine in advance of the hardwood growth.

In the portion of the tract where the overwood has not been removed it is seriously interfering with the growth of the pine and should be removed. From observations made on this tract it appears that in underplanting our mixed hardwood stands with white pine following a damage cutting the remaining stand should not exceed a density of 0.5. Where the density is greater the pines grow very slowly and become slender and dwarfed. Furthermore, the overwood should be removed within a period of five or six years after the planting of the pine. If allowed to remain longer, its increasing density causes the pines to become so slender and dwarfed that they are a long time in recovering after it is finally removed. It should also be noted that the larger the pine the greater the damage to them in the removal of the overwood.

It is believed that when a mixed hardwood stand is underplanted with pine in the hope of converting the hardwood to a softwood stand a spacing of 6 by 6 feet, or even 8 by 8 feet, is sufficiently close where the overwood is removed at the proper time, as the resulting stand will be partially composed of hardwoods which come in between the pines with the removal of the overwood. Furthermore, in underplanting seedling stock can be used with much more assurance of success than where the planting is done in the open, and particularly on grass-covered areas.

Although the best results can be obtained in removing the overwood in at least two cuttings at intervals of from three to five years, it is more economical to remove it at one cutting. Hence the latter method should usually be followed.

The cost incurred in converting a mixed hardwood stand to pines by a damage cutting, reducing its density to approximately 0.5 and planting, depends largely upon the possibility of a close utilization of the hardwood stand. Where the damage cutting will pay or more than pay the cost of its removal, the increased growth of the remaining stand will usually recompense the owner for the added cost due to removing the hardwoods in two cuttings instead of one.

The age of the stock used, the spacing, and the cost of setting the plants are approximately the same as on recently felled areas. Where complete utilization is possible, therefore, and there is no added expense in removing the hardwoods in two cuttings, the actual cost incurred per acre in converting a hardwood stand into pine is approximately as follows:

Cost of stock, including transportation (two-year old seedlings, 6 feet by 6 feet)	$3.00
Cost of planting, including supervision	4.00
Total	$7.00

Where close utilization is not possible, the cost incurred in making the damage cutting and later removing the overwood may so far exceed the cost incurred in the removal of the stand in one cutting that the expense of the liberation cleanings necessary when the area is clear cut and later planted may be considerably less. Under such conditions it is usually advantageous to clear cut and plant pine the following spring, with the expectation of an expenditure of at least $3 per acre for liberation cuttings before the pine is sufficiently large to suppress the sprouts and seedling hardwoods.

Most chestnut lands in southern New England are suitable for the growth of white pine or red pine. White pine in particular thrives on a great variety of soils and under varying conditions of soil moisture. It is believed that it would be economically advantageous to change over many of our diseased chestnut stands to this species where the change can be accomplished at moderate cost. Where the chestnut comprises 40 per cent or more of the stand, there is little hope that when it is cut the new crop of sprouts will form an acceptable forest because of the diseased condition of the chestnut. In such stands two courses are open: first, the removal of the entire stand and its replacement the following spring by planting two-year-old seedling white pine; second, the removal of the chestnut in a damage cutting and underplanting the remainder of the stand with two-year seedling white pine, with the expectation of removing the overwood as soon as it interferes with the growth of the pine.

Where chestnut comprises less than 40 per cent of the stand, it is usually possible to develop a satisfactory stand of other hardwoods, particularly if the stand is still young, through damage cuttings, which include the removal of all the chestnut.

In many hardwood forests the chestnut is very unevenly distributed, in places including 40 per cent or more of the stand, while in others it may form but a small percentage. In such forests it is very desirable that damage cuttings be made as early as possible, followed by the planting of pine where the stand is opened up to a density of 0.5 or less through the removal of the diseased chestnut. Under such a procedure the resulting stand would be a mixed forest of pine and hardwoods in groups with the chestnut eliminated. The average cost per acre would depend upon the utilization of the material removed in the damage cutting and the percentage of the area planted with pine. Where close utilization is possible, the cost may be as low as $2 or $3 per acre. As a result of this expenditure a complete stand of pines and hardwoods might be attained instead of an incomplete stand, often of inferior material, due to the diseased chestnut where no attention is given to the regeneration.

DISCUSSION

By Haven Metcalf

In a certain way this paper marks an epoch, for I think it is the first time, in the East at least, that it has been found necessary to take a forest disease sharply into account in formulating a forest policy. In New England the seriousness of the chestnut-bark disease has hitherto been treated with astonishing conservatism. The impression has been allowed to prevail that the disease was due to weather conditions and would soon disappear of itself, and hence was not worth serious attention. It is very unfortunate, both from the standpoint of pure science and the standpoint of any ultimate control, that investigations were not inaugurated in many places and by many persons when the disease first appeared. As a matter of fact the disease is not mentioned in any official New England publication until 1908, and then with no appreciation of its real significance.

In southern New England or, more definitely, in Fairfield County, Connecticut, there is one of the oldest stations of the disease. Here individual trees were certainly infected as early as 1900, if we can judge by their appearance when first observed seven years later. In New England the spread of the disease has been distinctly east and north from the general neighborhood of New York City. In Rhode Island it appeared late enough so that fairly detailed studies of its spread in that State have been made. It now extends practically throughout the range of the chestnut in New England, the ultimate points of infection being Auburn and Temple, Maine, where it occurs on planted chestnuts. In Massachusetts it was present in 72 towns and cities by 1911, and this summer (1913) it has been found in 190.

It will clarify our ideas somewhat to consider the origin of the disease. It occurs in northeastern China, under conditions that lead us to believe it is indigenous there, on a small species of nut-producing chestnut tree. The exact identity of this species is not yet certain; it may be *Castanea mollissima.* Upon these trees in China the disease is apparently not very serious. It produces cankers which are not able to girdle the trees, but callus forms around them, and in this way deep cankers are ultimately formed, corresponding somewhat to the Gymnosporangium cankers on juniper in this country. Some limbs are killed, and very likely some young trees may be killed outright. In the '80's, and particularly in the early '90's, there was extensive importation of Asiatic nursery stock into this country, particularly the Japanese chestnut. There was every opportunity for the disease to come into this country along with the San José scale; there was no system of inspection or quarantine of any sort to interfere with the wholesale introduction of any disease or pest. Once here it found a wonderfully susceptible host in our American chestnut. This tree has practically no resistance to the fungus, and in consequence the cankers spread rapidly until they girdle the tree, instead of having their growth sharply delimited, as is the case on the Chinese tree and on most strains of the Japanese. So we have to deal with an invading organism which has attacked a wild species of tree growing largely under natural conditions and well within its natural range. The disease has now spread in natural chestnut growth from New Hampshire to Virginia, and from trees at sea-level, which actually overhang salt water, to an elevation of 2,000 feet in various parts of Virginia. So far as I can see, there is not the slightest change in the rate of progress of the disease in any locality, nor is it anywhere behaving differently from what it was when it first came under my observation in 1907.

Professor Toumey's whole proposition hinges on just what the disease is going to do. It is almost idle to try to prophesy in a case like this. The trouble is that we have no valid antecedent data from which to argue. We do not, I think, know of any case where an entire species of any plant has been wiped out by a fungous disease, but, on the other hand, we have no precedent of any epidemic of this character. We cannot argue from previous plant diseases that have been epidemic in this country, because all of these that have been carefully studied occurred on cultivated plants, growing under wholly different conditions from a native forest tree. We cannot argue from the behavior of imported weeds, insects, birds, or animals, as the biological conditions governing their distribution and spread are necessarily different from those that obtain in the case of a fungous disease. All that we have to argue from is the behavior of this disease itself since it has been under observation. On this basis I cannot see anything in sight except the complete destruction of the present commercial stand of chestnut, at least north of the Potomac, and the only thing I can see south of the Potomac that will avert a similar catastrophe is the efforts to control the disease that are being made by the States of West Virginia and Virginia. Both of these States started work early, while there was still relatively little of the disease present.

In a very few years we may expect that the chestnut country north of the Potomac will present the same appearance that we now see on Long Island and in the neighborhood of New York City—that is, the epidemic will be reduced to a struggle between the fungus and the sprouts. The regenerative power of the chestnut tree is remarkable. On Long Island I have had certain trees under observation since 1907. Beginning with 1907, they have put up a new crop of sprouts each year—seven crops in all to date—but in no case have any of these been able to reach the third year without being attacked by the fungus. From this we can see that the ultimate outcome may be more hopeful than would have been the case if the fungus had attacked a species which had not the remarkable sprouting ability of the chestnut.

In this connection I might say that, so far as disengagement cuttings are concerned in the plantings which Professor Toumey proposes, it will not be necessary to consider chestnut sprouts, since, according to our observations on Long Island, the disease will attend to them, and those appearing after the second year are not very vigorous. Of course, any sprouts from other hardwoods will behave in their normal way.

Regarding white pine, we must remember that this tree is subject to another imported disease, the blister rust, which is potentially quite as serious as the chestnut-bark disease. Thanks to the regulations of the Federal Horticultural Board, it is no longer possible to make wholesale importations of blister rust from Europe; but the disease is undoubtedly still present in many places, particularly in New York and New England. Compared with the chestnut-bark disease, its control should prove easy. But until we can be reasonably sure that there is no blister rust left in the country, we cannot exclude the possibility of grave danger from this source in any consideration of white pine. The blister rust will not be eradicated until more serious and more uniform action is taken against it by all interests concerned.

NOTES ON THE BILTMORE STICK

BY DONALD BRUCE

Contributed

The Biltmore stick is no longer a mere experiment. In practical service in many parts of the country, it has proven itself far more convenient than calipers and in accuracy quite satisfactory for the purpose for which it is used. But though its effectiveness is well established, yet its use is still so far from universal that a few further suggestions as to its most desirable construction, its advantages and its limitations may perhaps be of interest.

The formula usually given for calculating the values to be laid off on a Biltmore stick is $s = \frac{ad}{\sqrt{a(a+d)}}$. This formula, first published in the September, 1911, number of the Forestry Quarterly, is entirely correct mathematically, but deserves a caution in its use lest a considerable error be introduced. In its derivation the stick is represented by a line tangent to the circular cross-section of the tree. To have the graduations on a stick constructed according to this formula assume this position, it is necessary either to bevel the edge of the stick or to hold the stick with the graduated face horizontal. There are many advantages, however, in having the stick square-edged and in having the graduations held facing the eye. Both of these conditions can be attained by the use of the formula $s = \frac{d(a-t)}{\sqrt{a(d+a)}}$, in which t, the thickness of the stick, is an additional factor.

This is derived as follows:

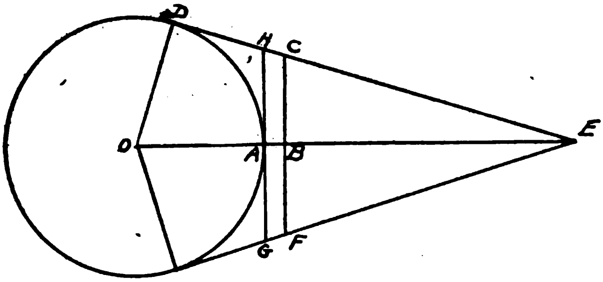

FIGURE 1

Let the circle O be the cross-section of the tree, C F G H a portion of the stick, and E the position of the eye.

Also, let $s =$ the graduation distance on the stick $= CF$

$a =$ the arm's-length $= EA$

$t =$ the thickness of the stick $= AB$

$d =$ diameter of the circle $= 2\ OD = 2\ OA$

Since the triangles CBE and ODE are similar,

$$CB : BE = OD : DE$$

or, $CB \times DE = OD \times BE$

Since ODE is a right triangle, $DE = \sqrt{OE^2 - OD^2}$

(1) Substituting, $CB \times \sqrt{OE^2 - OD^2} = OD \times BE$,

But, $CB = \frac{S}{2}$, $OE = \frac{d}{2} + a$, $OD = \frac{d}{2}$, $BE = a - t$

Substituting, in (1) $\frac{s}{2}\sqrt{\left(\frac{d}{2} + a\right)^2 - \left(\frac{d}{2}\right)^2} = \frac{d}{2}\ (a - t)$

Reducing, $s\ \sqrt{(d + a)\ a} = d\ (a - t)$

and, $s = \dfrac{d\ (a - t)}{\sqrt{a\ (d + a)}}$

It will be noted that when $t = 0$ this formula reduces readily to that usually given.

It might not seem that the error involved in disregarding the thickness of the stick where this is as small as ¼ inch would be serious. It is, however, far from negligible. Expressed algebraically, it is equal to the difference between the two formulæ, or,

$$\frac{ad}{\sqrt{a\ (a + d)}} - \frac{d\ (a - t)}{\sqrt{a\ (a + d)}}.$$

Reducing, this becomes $\dfrac{dt}{\sqrt{a\ (a + d)}}$.

This expresses the error in terms of distances on the stick, which can be reduced easily to inches in diameter by interpolation in the table given below. If t, the thickness of the stick, is taken as ¼ inch, the following values are obtained for trees of various diameters:

D. B. H.	Error	
	Distance on Stick	Diameter
10 inches	.08 inch	.2 inch
30 inches	.2 inch	.4 inch
60 inches	.3 inch	1.0 inch

The fact that this error is constant in sign adds further to its importance.

The following table gives the values of s calculated from both the original and the revised formulæ, for arm's-lengths ranging from 23 to 27 inches and for diameters from 6 to 60 inches. The columns headed $t = 0$ are derived from the original formula and those headed $t = ¼$ are from the revised formula, with the thickness of the stick assumed to be ¼ inch:

Diameter breast high (d)	Distance (a) from eye to tree—inches									
	23		24		25		26		27	
	Actual distances (s) to be marked on stick—inches									
In.	$t=0$	$t=\frac{1}{4}$	$t=0$	$t=\frac{1}{4}$	$t=0$	$t=\frac{1}{4}$	$t=0$	$t=\frac{1}{4}$	$t=0$	$t=\frac{1}{4}$
6..	5.34	5.29	5.37	5.31	5.39	5.34	5.41	5.36	5.43	5.38
8..	6.89	6.82	6.93	6.85	6.96	6.90	7.00	6.93	7.03	6.96
10..	8.35	8.26	8.40	8.31	8.45	8.36	8.50	8.41	8.54	8.46
12..	9.73	9.67	9.80	9.69	9.86	9.76	9.93	9.83	9.99	9.89
14..	11.03	10.92	11.13	11.01	11.21	11.09	11.29	11.17	11.37	11.25
16..	12.29	12.15	12.40	12.26	12.50	12.36	12.59	12.46	12.68	12.56
18..	13.49	13.34	13.61	13.47	13.73	13.59	13.84	13.70	13.95	13.81
20..	14.63	14.46	14.77	14.61	14.91	14.75	15.04	14.89	15.16	15.02
22..	15.72	15.55	15.89	15.72	16.05	15.89	16.19	16.05	16.34	16.19
24..	16.79	16.60	16.97	16.79	17.14	16.95	17.30	17.11	17.46	17.30
26..	17.81	17.62	18.01	17.82	18.20	17.99	18.38	18.20	18.55	18.38
28..	18.80	18.59	19.02	18.82	19.23	19.04	19.43	19.24	19.62	19.44
30..	19.76	19.55	20.00	19.79	20.22	20.02	20.44	20.24	20.65	20.46
32..	20.69	20.47	20.95	20.72	21.19	20.97	21.42	21.21	21.65	21.45
34..	21.59	21.36	21.86	21.64	22.13	21.91	22.38	22.16	22.63	22.42
36..	22.47	22.23	22.76	22.52	23.04	22.81	23.30	23.08	23.56	23.35
38..	23.32	23.07	23.64	23.38	23.94	23.69	24.23	23.99	24.49	24.27
40..	24.17	23.91	24.49	24.24	24.80	24.56	25.10	24.86	25.40	25.16
42..	24.98	24.71	25.32	25.05	25.65	25.38	25.96	25.71	26.27	26.03
44..	25.78	25.50	26.13	25.87	26.48	26.23	26.81	26.55	27.13	26.89
46..	26.55	26.26	26.93	26.65	27.29	27.01	27.64	27.36	27.98	27.72
48..	27.31	27.01	27.71	27.41	28.09	27.80	28.46	28.17	28.80	28.54
50..	28.07	27.76	28.48	28.18	28.86	28.57	29.24	28.96	29.61	29.34
52..	28.79	28.48	29.22	28.91	29.63	29.32	30.02	29.72	30.40	30.11
54..	29.51	29.18	29.95	29.63	30.38	30.06	30.79	30.48	31.18	30.89
56..	30.22	29.88	31.11	30.35	31.53	30.79	31.94	31.22	32.33	31.64
58..	30.90	30.56	31.38	31.04	31.83	31.49	32.27	31.94	32.69	32.38
60..	31.58	31.23	32.07	31.73	32.54	32.20	33.00	32.67	33.43	33.12

A number of field tests of the accuracy of the stick have been made and published. All have proven conclusively that when carefully used the Biltmore stick will give results entirely consistent with the accuracy demanded in reconnaissance work. In general, the average error has been shown not to exceed that of the calipers by more than 1 to 2 per cent.

The sources of error are also well recognized. Obviously, for complete accuracy the following conditions must be fulfilled:

The tree must be circular in cross-section.

The stick must be held against the tree at a point 4½ feet from the ground.

The eye must be on a level with the stick (assuming that the tree is erect).

The eye must be at the proper distance from the tree.

The stick must be held horizontal (assuming again that the tree is erect).

The stick must be held perpendicular to the line of sight from the eye to the center of the tree at the point of measurement.

An investigation into the relative importance of the errors arising from a departure from any one of these conditions results in an interesting comparison. In four of the six—all but the first two—the error can easily be defined mathematically. Obviously, the extent of the error will vary with the diameter of the tree measured, and as a unit of measure the limit of error in diameter resulting from the various causes of error may be taken as 1 per cent of the diameter. At first thought it might seem that a better unit would be some constant fraction of an inch; that six-tenths of an inch in the case of a 60-inch tree would result in a vastly more important error in volume than would one-tenth of an inch in the case of a 10-inch tree. However, it may be easily shown that each increases or decreases the basal area (and therefore the volume, since the height factor is separately determined) by almost exactly 2 per cent.

As previously stated, the eye should be held on a level with the stick, provided the tree is erect. A more general statement of the same idea is to say that the eye should be in a plane perpendicular to the axis of the tree at the point of measurement. The intersection of this plane with a regular tree will be a circle. If, however, the eye is not in this plane, the new plane in which it lies will intersect the tree in an ellipse. Two errors are introduced thereby:

a. The measurement is now being taken at a distance greater than the radius from the center of the section.

b. The line from the center to the point of tangency of the lines of sight is not perpendicular to the tangent. Graphic tests have shown that the latter error is negligible where the ellipse is one of such small eccentricity as will normally be produced in this case. The former error will then be seen to be similar to that involved in disregarding the thickness of the stick except that the distance from the line in which the measurements are taken to the eye is not reduced by an amount equal to that by which the distance from that line to the center is increased. Figure 2 shows this relation.

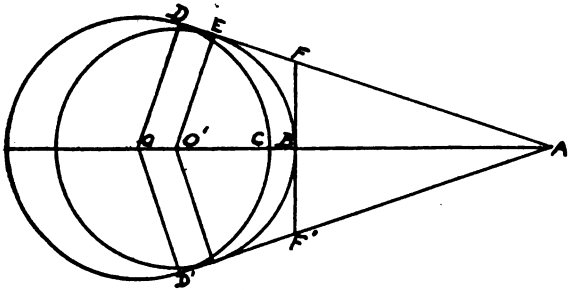

FIGURE 2

Let the circle O be the cross-section of any tree which is being measured by a stick placed at FF′, and AD and AD′ the tangents representing the lines of sight. The reading on this stick will be the same as that on a circle, O′, which represents an imaginary tree which is tangent to both AD, AD′, and FF′. The problem is, given that the diameter of the circle O′ is smaller than the circle O by 1 per cent, to find the distance CB.

Now $CB = O'B - O'C$

and $O'C = OC - OO'$

(I) $\therefore$ $CB = O'B - OC + OO'$

Since AOD and AO′E are similar triangles,

$$\frac{AO}{AO'} = \frac{OD}{O'E} = \frac{OC}{O'B}$$

and, $$\frac{AO - AO'}{AO'} = \frac{OC - O'B}{O'B}$$

but, $AO - AO' = OO'$

$$\therefore \quad \frac{OO'}{AO'} = \frac{OC - O'B}{O'B}$$

(II) and, $$OO' = AO'\frac{(OC - O'B)}{O'B} = (AB + O'B)\frac{(OC - O'B)}{O'B}$$

Combining I and II, $$CB = O'B - OC + (AB + O'B)\frac{(OC - O'B)}{O'B}$$

Let r = the radius of circle O
and r' = the radius of circle O′
and a = the arm's-length, or AB.

Substituting, $$CB = r' - r + (a + r')\,\frac{(r - r')}{r'}$$

$$= \frac{r'^2 - rr' + ar - ar' + rr' = r'^2}{r'} = \frac{a\,(r - r')}{r'}$$

But $r' = \frac{99}{100}r$

$$\therefore \quad CB = \frac{a\,\frac{1}{100}r}{\frac{99}{100}r} = \frac{1}{99}a$$

and if $a = 25$ inches

$$CB = \frac{25}{99} = .25 + \text{inches.}$$

In other words, if the stick is held .25 inch further than the radius from the center of any tree, irrespective of diameter, an error of 1 per cent will result. It only remains to determine how far the eye can be out of its proper plane to produce an elongation of this amount in the line from the center to the point of measurement.

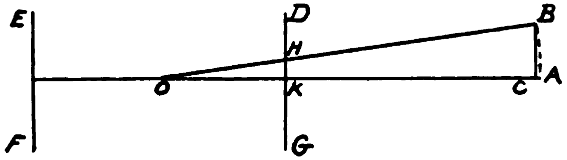

FIGURE 3

Assuming that that portion of the tree close to the point of measurement is cylindrical, Figure 3 shows a vertical cross-section in which DG and EF are the two sides of the tree, A is the proper position of the eye and B is the false. Draw BC perpendicular to AO. Let $r = OK$, the radius.

And $HO = r + .25$. Now $BH = AK = 25$ inches

Since BCO and HKO are similar triangles $BC : HK = BO : HO$

$$\text{or, } \frac{BC}{\sqrt{HO^2 - OK^2}} = \frac{25 + r + .25}{r + .25}$$

$$BC = \frac{25.25 + r}{.25 + r} \sqrt{.25^2 + .5\,r}$$

Solving, when $r = 5$, 15, and 30, to give a range of diameters, we have $BC = 9.2$ inches, 7.3 inches, and 7.1 inches, respectively. In other words, the eye must be 7.1 inches above its proper plane in the case of a 60-inch tree before an error of 1 per cent in diameter results.

If a stick is not held in a horizontal position when the tree is erect, or, expressed more generally, if it is not held in a plane perpendicular to the axis of the tree, the intersection of the plane of observation with the tree is again an ellipse. The extent of this error may be calculated comparatively simply. The planes in which the eye may move in observing either side of the tree and the plane in which the stick moves, so long as no other source of error is introduced, will intersect in two lines which are essentially parallel.

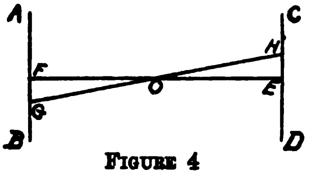

FIGURE 4

In Figure 4, AB and CD represent these lines, FE the correct and GH the erroneous position of the stick. Then FE will $= s$, the value corresponding to the diameter of the tree, and if we figure once more on a 1 per cent error, GH will be equal to $s_{1.01}$ or the value of s corresponding to a diameter 1 per cent greater than that of the tree. This value of GH may be obtained with sufficient accuracy by interpolation from the above given table.

In the figure, $\cos \text{ angle } HOE = \dfrac{OE}{OH} = \dfrac{\frac{1}{2}\, s}{\frac{1}{2}\, s_{1.01}} = \dfrac{s}{s_{1.01}}$

Solving for 10, 30, and 60 inch trees, we have

D. B. H.	Angle from horizontal at which stick may be held to produce 1 per cent. error, D. B. H.
10 inches............	7° 20′
30 inches............	6° 44′
60 inches............	6° 29′

If the stick be 36 inches long this is equivalent to holding one end of the stick higher than the other by 4.6, 4.2, and 4.1 inches, respectively.

When the stick is held in the proper horizontal plane, but not perpendicular to the line of sight, the cross-section of the tree in the plane of observation is a circle. In Figure 5 this circle is represented by the circle E, and CH is the true and FG the false position of the stick. Attacking this problem on the same basis as the previous cases, CH is then the value of s corresponding to the diameter of the tree, and FG is the value of s corresponding to a diameter 1 per cent greater than that of the tree, or $s_{1.01}$.

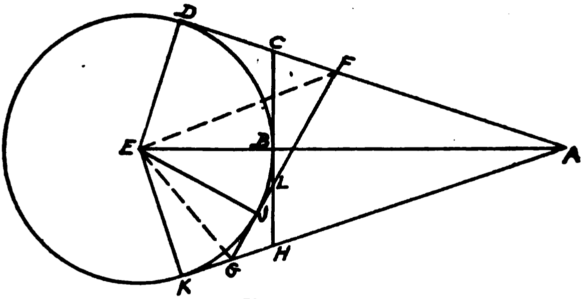

FIGURE 5

Let x $=$ angle CLF $=$ angle BEJ

Now Angle ACB $=$ angle DEB

Angle DEJ $=$ angle DEB $+$ angle BEJ $=$ ACB $+$ x

Angle KEJ = angle KEB — angle BEJ
but (Angle KEB = angle DEB = angle ACB)
∴ Angle KEJ = angle ACB — x
Now Angle FEJ = ½ angle DEJ
and Angle GEJ = ½ angle KEJ
Also let r = radius of the circle E = EJ

$$\frac{FJ}{EJ} = \tan \text{ angle FEJ}$$

$$\text{(I) Or } \frac{FJ}{r} = \tan \tfrac{1}{2} \text{ angle DEJ} = \tan \tfrac{1}{2} (\text{angle ACB} + x)$$

In a similar manner $\frac{GJ}{EJ} = \tan$ angle GEJ

$$\text{(II) Or } \frac{GJ}{r} = \tan \tfrac{1}{2} \text{ angle KEJ} = \tan \tfrac{1}{2} \text{ angle } (\text{ACB} - x)$$

Adding (I) and (II), $\frac{FJ + GJ}{r} = \tan \frac{1}{2} (\text{angle ACB} + x)$

$$\tan \tfrac{1}{2} (\text{angle ACB} + x)$$

But $FJ + GJ = FG = s_{1.01}$

and, Angle ACB $= \tan^{-1} \frac{25}{\frac{s}{2}} = \tan^{-1} \frac{50}{s}$

$$\therefore \frac{s_{1.01}}{r} = \tan \tfrac{1}{2} \left(\tan^{-1} \frac{50}{s} - x\right) + \tan \tfrac{1}{2} \left(\tan^{-1} \frac{50}{s} + x\right)$$

Reducing by regular trigonometric formulæ, and letting

$\tan \frac{\tan^{-1} \frac{50}{s}}{2} = T$, we have

$$x = 2 \tan^{-1} \sqrt{\frac{s_{1.01} - 2rT}{T(s_{1.01}T + 2r)}}$$

Substituting in this equation the values for s and $s_{1.01}$ for trees of different diameters obtained directly and by interpolation from the table given above and solving for x, we obtain the following results:

D. B. H.	Angle by which stick may vary from correct position to result in error of 1 per cent. in D. B. H. reading.
10 inches............	7° 48′
30 inches............	7° 52′
60 inches............	8° 14′

Assuming that the stick is 36 inches long, this can also be expressed by saying that one end of the stick may be nearer than the other to the eye by 4.9 inches, 4.9 inches, and 5.1 inches, respectively.

The remaining error which can be expressed mathematically is that resulting from an error in the arm's-length. Figure 6 makes this relation clear.

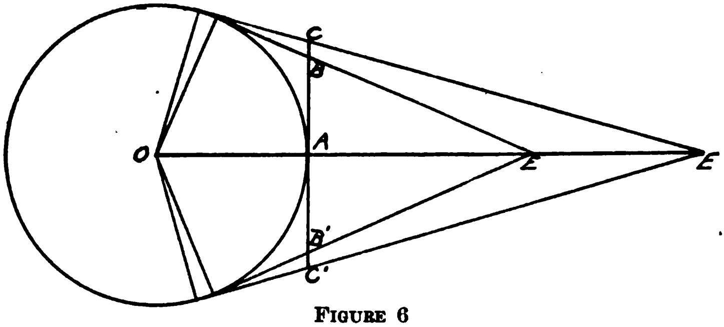

FIGURE 6

In this E is the correct position of the eye and E′ the erroneous.

Then BB′ = s, or the value corresponding to the true diameter, and
CC′ = $s_{1.01}$ of the value corresponding to a diameter 1 per cent greater than the true diameter.

Let EE′ = e, the error in position of the eye.

The formula for $s_{1.01}$ is obviously exactly similar to that for s except that a + e will be substituted for a. The result will be $s_{1.01} = \sqrt{\frac{d^2 \ (a+e)}{a+e+d}}$

In a similar way

$$s_{.99} = \sqrt{\frac{d^2 \ (a-e)}{a-e+d}}$$

The results given for the two formulæ are so nearly identical that only the former need be solved.

Substituting the proper values for $s_{1.01}$ d, and a, and solving for e, we have

D. B. H.	Error in arm's-length which will produce an error of 1 per cent. in D. B. H.
10 inches............	1.5 inches
30 inches............	.62 inch
60 inches............	.44 inch

The error involved in taking the measurement at the wrong height from the ground is exactly the same as with the calipers and depends, of course, entirely upon the taper of the tree. The tendency with the Biltmore stick is, however, strongly toward measuring high on account of the inconvenience of stooping, and the sign of the error is therefore almost always negative. The possible advisability is suggested of having volume tables constructed for Biltmore-stick work based on diameter eye high. While this would prove considerably more convenient, yet the error from this source with the usual form of tables is due wholly to carelessness and can be practically eliminated.

Irregular trees are particularly difficult to measure with the Biltmore stick. This is true for two reasons. Taking the case where the cross-section of a tree is a true ellipse, for example, it can easily be seen that if the measurement be taken with the eye on line with the long axis, not only is the smallest diameter being observed, but the stick is being held at too great a distance from the center. This results in a minus error of 1 per cent, it was shown in the discussion of the error, due to having the eye above the level of the stick, where the additional distance is only ¼ of an inch. In other words, any measurement of a short diameter will result in readings even smaller, and conversely the values obtained from the measurement of a large diameter will be increased through the fact that the stick is too near the center. All the errors of the calipers, therefore, are exaggerated, whether positive or negative. Furthermore, but few regular trees are true ellipses, and if the cross-section is at all egg-shaped decidedly different results will be obtained in taking measurements from diametrically opposite points. This is due to the fact that the stick takes its measurements between diverging lines, thus introducing an error which the parallel lines of the calipers avoid.

The infinite possible variations in the shape of irregular trees make investigation of any specific form of little value. Graphic tests show, however, that in the case of an ellipse of moderate eccentricity the average of measurements taken of the long and short diameters is correct within a negligible error. However, a single measurement taken from a point opposite an average diameter gives values considerably too large. Quite accurate figures can be obtained if the stick is held against the tree at a point where it is at the end of an average radius. Such a point is, however, difficult to determine accurately. A quite precise measurement of a decidedly irregular tree is the average of four measurements taken from points 90° apart around the tree.

Practically, however, in such work as reconnaissance this question of irregular trees is of minor importance. Comparatively few trees vary widely from a circular cross-section, and if these are measured from the most convenient side, regardless of possible abnormality, whatever error is involved in any individual tree will be largely compensated in the total estimate.

The following summary table, which gives the sign as well as the extent of each, will make the influence of the various sources of error as above calculated more easy to compare.

Table of Errors in Using Biltmore Stick

Sign	Cause	Resulting in error of 1 per cent. in diameter.		
		D. B. H. of trees.		
		10"	30"	60"
—	Eye above or below stick by.........	9.2"	7.3"	7.1"
+	Stick not horizontal—one end higher than other by......................	4.6"	4.2"	4.1"
+	Stick not perpendicular to line of sight—one end nearer the eye than the other by......................	4.9"	4.9"	5.1"
±	Eye too near to or too far from tree by	1.4"	.65"	.45"
Usually —	Measurement at wrong height........	(Variable.)		
±	Tree irregular in shape.............	(Very variable — considerably greater than with calipers.)		

It is at once apparent that the one error which dominates all the others is that resulting from having the eye at the wrong distance from the tree. Only gross carelessness could result in variations as large as are indicated by the first three items in the table, but to consistently keep the arm's-length within .45, or even .65 of an inch of the correct value, is a matter of considerable difficulty. Fortunately, both this and the error resulting from irregular trees are compensating. Moreover, the errors fixed in sign are not only small, but, since two are positive and two negative, will largely compensate each other. The general conclusion of previous empirical tests is thoroughly confirmed that if the arm's-length is carefully watched no hesitancy need be felt over using the stick for work of the accuracy demanded in reconnaissance.

The convenience of the stick for certain kinds of work may be considerably increased by entering directly upon its two surfaces the values of the volume table most in use in somewhat the same manner as the figures on an ordinary scale stick. Four columns of figures may be entered on each face. Reserving one on each for the d. b. h. values, this leaves six columns for trees of different log lengths. If more are needed, the upper end of the one-log tree column can be used for seven log trees, etc. The simplest method is to enter opposite the six-inch d. b. h. graduation the volume table values for trees of that diameter and of each height class. Greater convenience in interpolations is, however, obtained by regraduating each column so that the even tens and hundreds can be shown. This may be done by redrawing the volume curves from the volume table, putting the volumes not over the diameters in inches, but over the s values corresponding to these diameters. From these curves the proper spacings of the graduations can be taken directly.

Such a stick may be used similarly to one of the ordinary model, except that the merchantable height of each tree is carefully estimated in logs before putting the stick against it. Then, choosing the proper column, the volume of the tree in feet, board measure, may be read directly from the stick. If these are entered in column on a simple form, a single addition completes the work of computation.

The advantage gained through eliminating a step in the computation is obvious. On the other hand are equally evident disadvantages which restrict its use to special cases. In the first place no record is kept of the diameters and heights of the trees tallied, and in the second it is accurate only for the species for which it is constructed. This latter difficulty can, however, be largely overcome by the use of tables of species coefficients. The following example will show what is meant by this term. For use with a stick constructed for western white pine, a table was prepared which showed the percentage ratio between the values of a western larch volume table and that of the western white pine. Larch was chosen on account of its thick bark, which would naturally make its variation from the white pine more decided than that of most other species. From this table the following converting factors were deduced by inspection:

		Per cent.
Trees up to	14 inches add	1
Trees up to	20 inches add	2
Trees averaging	18 inches add	4
Trees averaging	24 inches add	10
Trees averaging	28 inches add	13
Trees averaging	32 inches add	15

These corrections are to be made at the same time that the cull per cent is being applied, the average size of the trees being estimated. In a rough test for accuracy five 40 sheets were taken at random from data actually collected by an Idaho reconnaissance crew, and the larch values calculated both directly from the larch volume table and indirectly by means of the white-pine table and the above table of converting factors. The error ranged from .7 of 1 per cent to 4 per cent. The average error was 1.5 per cent and the aggregate only .3 of 1 per cent. This test was, of course, too limited to be conclusive, but is a decided indication of the possibilities of this form of stick where some one species is of dominant importance.

One further point may be worth mentioning. The chief advantage of the Biltmore stick is claimed by many to be its speed. Tests made by reconnaissance crews in Idaho during the past summer do not support this statement without qualification. Where all the trees on a given strip were being actually measured, the calipers proved considerably faster on account of the fact that the care necessary in getting the arm's-length correctly consumes considerable time. However, ease in carrying and the large range of diameters offered seems of dominant importance where all that is required is an occasional check upon ocular diameter estimates, and it is for this reason that the Biltmore stick is so rapidly increasing in popularity.

MANAGEMENT OF WESTERN WHITE PINE

BY D. T. MASON

Contributed

Recent investigation in District 1 has developed a number of new facts which entirely upset many old theories with regard to white pine. During the fall of 1913 Assistant Forester Greeley, with members of the District, covered the white-pine region in northern Idaho, northwestern Montana, and northeastern Washington quite thoroughly with the object of outlining a system of cutting applicable to the white-pine type throughout the region.

A brief statement will here be presented of the important characteristics of white pine bearing on its management. White pine has heavy seed years at intervals of four to seven years, the average interval having not yet been determined. A light yield of seed occurs nearly every year. The old idea that white pine reseeds abundantly for great distances by wind dissemination has been proven incorrect. Although the seed is sometimes blown for distances of one-half mile or more, the amount so disseminated is so small that only a partially stocked stand results. Usually seed travels only from two to three chains from the base of the parent tree in sufficient quantities to restock cut-over areas promptly and in a satisfactory manner.

White-pine seed has one unusual and extremely important characteristic—that is its tendency to lie dormant for one or more years after sowing. Even under the optimum conditions produced in nursery seed beds, most of the seed does not germinate promptly, but lies over for at least one year, usually giving a far better germination the second spring than the first one, following sowing. Investigations not yet completed appear to indicate that a small per cent—less than 10 per cent of the viable seed in all tests made to date—germinates fairly promptly under ordinary conditions. The remainder of the seed is sluggish and seems to require for germination a somewhat higher temperature than ordinary—such a temperature as would be found at the surface of ground fully exposed to the sun as compared with that in a dense forest. Thus considerable white-pine seed that has fallen in the duff under mature white-pine forests remains viable yet dormant, under conditions approximating cool storage, for several seasons—just how long is not yet definitely known. However, investigations indicate that an average of about one seed per square foot is stored in the duff. Many of these seeds are found by cutting tests to be hollow, dried out, bleached, or discolored, yet enough of them to make a total of several thousand per acre are white and firm and apparently good. At any rate, examination of thirty areas has shown that whenever such a stand is cut and the duff is exposed to the sunlight a germination averaging well over 1,000 per acre has resulted from this stored seed. Usually 25 to 40 per cent of this stand of seedlings germinates the first season following cutting; 30 to 60 per cent in the second season, and a small amount during the next two years.

It was formerly believed that a mineral seed bed was required for white-pine germination; now it is certain that such is not the case. In fact, seedlings starting on duff appear to have a better chance of surviving through the first growing season than those starting on mineral soil, since the duff conserves the moisture in the mineral soil beneath, while the exposed mineral soil is apt to dry more rapidly and thus produce moisture conditions not favorable to the survival of young seedlings. On cut-over areas which have had the brush disposed of by broadcast burning, it is found that most of the reproduction is on the small areas of unburned duff which escaped the slash fire, some on scorched duff, none on severe burns that have exposed the mineral soil, excepting those that have come in by wind dissemination after the burning, and a number on mineral soil which has been stirred up and the seed stirred into it by the logging operation. The most abundant reproduction from seed stored in the duff occurs following the cutting of young stands from 100 to 140 years in age, while much less abundant reproduction follows the exposure of duff when stands 160 years or more in age are cut. This, of course, is due to the fact that the more vigorous young stands have produced and stored much more seed than the older stands. It is not necessary that the cutting be absolutely clean to secure satisfactory germination of the stored seed, but a large amount of light is required, such, for instance, as would result from the removal of 70 per cent or more of volume of the stand.

Under almost all stands the careful inspection of the ground reveals many puny white-pine seedlings from one to eight or ten years old. These are absent usually only when the shade is extremely heavy. Most of these seedlings persist for a few years and finally die, unless light is admitted to them either by some accident, such as windfall, insect destruction, etc., or by cutting of the stand. This advance growth is usually very small and much of it escapes damage in the course of an ordinary logging operation if the brush is piled and burned.

A study with the object of determining the proper spacing for use in planting work, when no thinning can be counted upon, and when a maximum volume production of rough lumber is desired, indicates that plants spaced evenly 9 by 9 have the combination of height and diameter growth which give the maximum production in volume up to about 50 years. This is at the rate of about 540 seedlings per acre. The white-pine reproduction on areas cut over in fairly heavy stands of timber where the brush has been piled and burned and the duff preserved, including both advanced growth and the seedlings started from stored seed in the first three or four years after cutting, usually occurs at the rate of from 1,000 to 3,000 or 4,000 seedlings per acre. This is sufficient to give a satisfactory stand, excepting when the distribution of the seedlings is extremely poor.

White pine is in many ways a rather delicate tree. A fire running through the stand, even though very light, will kill many of the trees outright. Those which are not killed directly by the fire are extremely likely to be killed within a short time by insects which start in the weakest of the trees. These insects are apt to kill most of the remaining stand eventually, and in many cases spread out into unburned stands in the vicinity. This state of affairs is strikingly shown in many places following the 1910 fires. Even where there has been no fire for many years, insects are at work killing single trees and small groups of trees here and there throughout the stand. Fungi also do a large amount of damage to white pine. In stands over 100 years old the amount of damage from this source usually increases fairly rapidly, although in exceptional cases individual trees escape injury to an old age. The great amount of damage done by insects has been fully appreciated only recently. On the other hand, it has been the general belief that white pine is very easily wind-thrown. As a matter of fact, this opinion was based on results on moist flats, where the tree is consequently shallow-rooted. On better drained soils on slopes, where the soil is fairly deep, as it generally is in the white-pine region, the tree is reasonably wind-firm.

As a result of the susceptibility of this species to damage by fungi, and particularly by insects, which generally succeed in doing a large amount of damage soon after the stands reach an age of 100 years, or in some cases even before, it appears to be certain that on the average white-pine stands give a maximum yield at about 100 years. Of course, in the exceptional cases, where well-stocked stands have, without accident, reached an older age, up to 160 years or so, extremely high yields are found on limited areas of the best quality, showing for such stands, 100 to 150 years old, a mean annual growth of as much as 1,000 feet per acre per annum. These yields are decidedly exceptional, however, and are found only when conditions are optimum and when the stand has escaped damage. Well-stocked stands at the age of 100 years, on sites of a fair quality, yield from 15 to 30,000 feet per acre. Later in the life of the same stand the chances are that the yield will become less, particularly for the white pine, while increasing for the more tolerant species. At the age of 100 years white pine yields reasonably large amounts of desirable saw timber on the average site. It appears therefore that the largest yield can generally be obtained with a rotation of approximately 100 years.

Trees with reasonably good crowns which have been more or less suppressed in a stand will respond to a cutting which gives them full light with a greatly increased rate of growth.

White pine is an intermediate tree in the scale of tolerance. Natural pruning is usually unsatisfactory in pure stands, but mixtures with more tolerant species, such as cedar, spruce, or white fir, cause a reasonably good degree of pruning. Mixed stands are also more desirable than pure stands, owing to less risk from fire, insects, and fungi. Larch is an especially desirable tree for mixture with white pine, since it is decidedly fire resistant. In case the stand is practically destroyed by fire, there are usually a few larch which escape and provide for some natural reseeding. Probably the most desirable mixture for general use is one consisting of cedar and larch with the white pine.

In the past a number of systems of cutting have been tried with white pine. The first provided for leaving seed trees. This system was tried on soil where white pine was not wind-firm, and most of the trees left went down, while the others were largely killed or damaged by fire, insects, and sun-scald. To eliminate this difficulty a system was adopted which left irregular blocks of timber on approximately 25 per cent of the area and including about the same per cent of the stand. This system largely eliminated wind-fall, which was its main object. In most of the cuttings done under both of these systems the brush was disposed of by broadcast slash burning. Undesirable species, such as hemlock and white fir, where unmerchantable, were felled on the clean-cut areas or girdled in the seed blocks of the second method. This broadcast slash burning was done partly with the object of getting rid of the brush to increase the safety of the area from the fire protection point of view and partly to expose mineral soil as was then believed to be necessary to secure the germination of white-pine seed. Unfortunately, in almost every instance this method of brush disposal was unsatisfactory, either because fire ran over the area when the brush was too wet, in which case a great amount of material was left unburned, or else the brush was too dry, in which case the fire escaped into the green timber adjoining the cutting area or left as seed blocks, doing a large amount of damage. When the brush was burned in the spring, fire sometimes lingered in snags or down logs and sprang to life during the fire season, causing a great expense for fire patrol during the danger season.

On the basis of the facts as above briefly indicated, and a large number of less important points too numerous to mention here, Mr. Greeley prepared the following marking rules for the Lolo Creek Chance on the Clearwater National Forest. This is a stand of approximately 600,000,000 feet, which is now being prepared for sale; the tract of 36,000 acres of merchantable timber includes practically all age classes, mixtures, sites, etc.

Silvicultural Plan for Lolo Creek Area

MARKING

For marking purposes, the stand is classified as:

(1) Agricultural areas.
(2) Mature white-pine stands.
(3) Overmature white-pine stands.
(4) Selection stands.

Agricultural Areas

Areas classified as chiefly valuable for agriculture will, without marking or other designation, be cut clean of all merchantable timber, excepting small groups of small material suitable for homestead improvements.

Mature White-pine Stands

These are areas containing upward of 30 per cent of white pine of from approximately 100 to approximately 180 years in age.

The object of marking is to harvest the mature timber by clean cutting, which furnishes the best conditions for white-pine reproduction, and to insure restocking both with white pine and with the tolerant species, cedar, spruce, and white fir, which form a desirable mixture and understory. It is expected that satisfactory white-pine reproduction will be secured from advance growth and seed stored in the duff. Sufficient timber will be reserved, however, to seed areas burned in brush disposal and to insure restocking in case the first reproduction is destroyed by fire.

Approximately 10 per cent of the merchantable volume of the stand should be retained in compact groups, the remainder being cut clean, excepting for a few individual white pine, cedar, and larch trees, as noted below. The groups reserved should contain, as a rule, from 12 to 15 trees of merchantable size. The groups should be spaced from 3 to 6 chains apart in each direction, reserving on the average 1 group on each 2 acres or 5 on each 10-acre block. Groups should be located as far as practicable on secondary ridges, knolls, and slopes, rather than on flats or in the bottom of draws. This is desirable (1) to reserve the most wind-firm timber, (2) to leave it in the best position for scattering seed, and (3) to retain groups which will interfere least with logging operations.

As far as possible, each group should contain at least three white pines, choosing the smaller and thriftier timber wherever practicable, together with several cedar, preferably trees too large for poles, with large, full crowns for wind protection, and larch, which is desirable because of its wind-firmness and fire-resistant qualities.

It is also desirable to include Douglas fir and spruce in the groups, and white fir, free from conk, where these species occur with the first three named. No special effort to select groups containing white fir should, however, be made. Groups containing mixed species are preferable to those of pure pine in order to (1) increase safety from wind-throw and fire and (2) insure reseeding of the tolerant species together with pine. On each acre two or three seed-bearing trees each of larch and cedar should be left; where such trees are not included in the seed groups, individuals should be reserved outside of the groups. Preferably cedar unsuitable for poles should be left, although if only pole trees are available they should be reserved. The larch are left with the idea that they will last over the next rotation as standards. They should therefore be sound, thrifty trees, with well-developed crowns.

While the groups should include the smaller and thriftier white pine wherever such trees are available, larger white pine up to approximately 30 inches in diameter should be retained where no smaller trees are available. Where it is necessary to leave large white pine, unusually defective trees should be chosen for the purpose, when possible. It is the object, in cutting the mature stands, to insure *natural* restocking with as large a percentage of white pine as possible; larger trees must therefore be included in the groups where no small timber is available. Sound, thrifty white pine, under 15 inches d. b. h., which may occur here and there will be retained as a rule, whether forming a part of reserved groups or not. The small scale of such trees, with the probability of greatly increased growth if held over the rotation, make it more desirable to retain them than to cut them now. They will also assist in restocking the ground with white pine. Wherever patches consisting largely of such small white pine occur, they should, of course, be utilized for seed groups, and, if of sufficient extent, cut under the selection system as defined below.

Since it will usually be impossible to come back for any of the trees left before the end of the next rotation, the trees left should be either those which are comparatively small and thrifty and may be expected to stand and make a rapid growth through the next rotation or they should be large and defective, thus representing only a small investment in seed trees. The following exceptions to this general rule should be aimed at when practicable: pole cedar should usually not be left, defective white fir should not be left, and medium size larch, with well-developed crowns, should be the ones selected for leaving.

In marking, the ground should be laid off roughly in blocks 5 chains square (2½ acres) and each block looked over for desirable groups. As a general rule, at least one seed group should be retained on each block and 5 groups on each 4 blocks. The trees to be reserved in the selected groups and as scattered individuals should be marked conspicuously.

Overmature White-pine Stands

These are bottoms and slopes of the "white-pine type" on which the pine timber is mainly overmature, exceeding 180 years in age, and where the original white-pine stand has usually been largely displaced by tolerant species such as cedar and white fir. The objects and methods of marking will be the same as in mature stands, discussed above, with the following exceptions:

(1) White pine over 180 years of age will be retained in seed groups only when so defective as to have but little merchantable scale.

(2) When no white-pine timber under 180 years or very defective trees over that age are present, no white-pine trees will be reserved. If reproduction of this species is not secured from seed stored in the ground, planting will be used, if possible.

(3) Groups of the other species, giving preference to larch, cedar, spruce, and Douglas fir, will be reserved, where no pine is available, to insure natural restocking in case planting is not possible, or to furnish a filler for wide-spaced white-pine plantations.

Selection Stands

These include:

(1) Stands in which white pine predominates, 100 years of age and younger.

(2) Slope and ridge stands consisting chiefly of white fir, larch, or Douglas fir, with more or less white pine, and occasionally yellow pine, in mixture.

The object of marking is to cut the more mature and defective timber and to leave a basis for a second cut within from 40 to 60 years, consisting of the smaller and thriftier timber and younger age classes. Occasional patches will be opened up sufficiently to bring about reproduction of the less tolerant species; but this is not an object in marking, which will be governed primarily by the condition of the timber.

The smaller and thriftier timber up to approximately 30 per cent of the merchantable volume should be reserved. In general, trees under 16 inches, d. b. h., will be retained unless clearly defective or too crowded, and trees over that size will be cut unless clearly of the younger age classes (under 100 years) and very thrifty, or unless required to furnish seed of desirable species, or in grouping the remaining timber to prevent wind injury. This limit, however, must be applied flexibly, the general purpose being to give the operator a sufficient cut while reserving from a fourth to a third of the thriftiest timber for further growth. The small timber should be thinned for good spacing, leaving free crowns, and to remove seriously defective trees. Trees should be reserved for seed on the edges of burns and other openings whether now stocked with young growth or not. This is necessary as insurance against future fires.

Where the stand occurs in more or less even-aged groups, as on some of the slope and ridge areas where the timber is chiefly white fir or larch and Douglas fir, groups containing the younger and thriftier timber should be reserved rather than individual trees. Approximately 30 per cent of the merchantable volume should be retained. The same method should be used in even-aged areas of larch and Douglas fir and on exposed sites where safety from wind is an important factor.

White and yellow pine should be favored in thinning crowded patches and in reserving seed trees on the edges of openings; otherwise, trees of these species should be marked in accordance with their condition and the principles outlined above. As far as practicable, three or four trees each of larch and cedar should be retained per acre where these species occur; otherwise, cedar trees containing poles 25 feet long and upward will be cut as a general rule, smaller pole trees being retained. Young, thrifty white fir up to approximately 14 inches, d. b. h., should be retained in white-pine stands as a general rule, except in thinning crowded groups. On upper slopes and ridges, however, where this species is more free from conk, it should be marked in accordance with the age and condition of the individual trees like other species.

SLASH DISPOSAL

Agricultural Areas

On agricultural areas which are cut clean slash will be burned as it lies, without piling. The construction of fire lines around the edges of agricultural land and cutting it up into such blocks as may be necessary to control the fire will be required before burning is done. These should be cleaned of all inflammable material except duff to a minimum width of 25 feet, and should have a 3-foot strip cut to mineral soil on the outer edge where necessary, in the judgment of the forest officer, for safe burning. Small groups of small material suitable for homestead improvements, which are to be left, will be protected by similar fire lines.

Other Areas

On all other parts of the sale area slash should be lopped and piled and burned by the purchaser under the direction of the forest officer. This is to save as much of the advance reproduction and white-pine seed stored in the duff as possible. Slash should be thrown up in compact "tepee" piles on the most open ground, with small stuff at the bottom and large limbs stacked on the outside of the pile. The latter should include all material up to and including 4 inches in diameter.

Slash should be piled as far as practicable against and around undesirable white fir (Cf. below), when burning in such locations will not injure reserved trees or desirable young growth, and in the patches of pure white fir reproduction on areas which are being cut clean with a view to pine reproduction; otherwise remaining trees and young growth should be protected as far as practicable in piling and burning.

DISPOSAL OF UNDESIRABLE WHITE FIR

As a general rule all white fir of merchantable size, whose cutting is desirable, should be marked, unless their trunks contain conks or show other defects which indicate plainly that the tree contains no merchantable logs.

On non-agricultural lands undesirable white fir which cannot be cut under the foregoing should be killed by (1) piling and burning slash around them or (2) by girdling, provided that no tree having a diameter of less than 4 inches will be required to be girdled. Girdling, which will be done by the purchaser, should ordinarily be used where there is not sufficient slash to kill unmerchantable fir by the first method or where there is danger, in burning slash, of injury to surrounding trees which are to be reserved. Girdling should be required by the forest officer at any stage in the operation when necessary in his judgment, either before or after slash burning.

Rules along practically the same lines were also prepared in a few other specific cases. In one case it was considered advisable to increase the size of the seed groups, left in cutting mature stands, to about 1½ chains square on unusually exposed situations. In another case the stand for the most part consisted mainly of large and unusually sound hemlock, with a few very large, sound white pine over 200 years old, scattered through the stand. Here it was considered advisable even on non-agricultural land, owing to the large amount of hemlock reproduction on the ground, to fell all of the trees, lop the tops, and resort to a broadcast slash burn, saving about 5 per cent of the stand in groups of hemlock from 8 to 10 chains apart. Here the plan was to restock the area to white pine by wide-space planting and allowing the hemlock to seed in as a filler. It was felt to be unwise to leave the very large white pine as seed trees, owing to the great investment involved. The latter is an extremely unusual case. The system of marking outlined above is now used as a guide in cutting in the white-pine type in District 1.

A PARTIAL SOLUTION OF THE HARDWOOD MILL AND LOGGING WASTE PROBLEM

BY R. C. PALMER

Contributed

It has been stated that the enormous wood waste is caused more by a lack of market than by lack of desire to utilize. Whether this is strictly the case or not, the lumberman who has a large amount of money tied up in timber can hardly be accused of a desire to go out and throw away his capital.

With the rapid strides made in the conservation of our forest resources, the lumberman stumpage owner has many angles from which to approach this problem, and in our study of practical methods of cutting down this great waste of timber we recognize the soundness of the principles of saving by using properly as well as saving in the sense that the word implies.

This same lumberman stumpage owner is, in fact, becoming more and more keenly interested in getting the most out of his timber, whether induced to do so because of a desire to keep pace with the times or brought face to face with actual necessity.

The fundamental ideas of proper utilization begin right where waste begins, and that is with the cutting of the timber. It is on this subject of waste and its relation to the efficiency of logging and mill operations that I wish your attention in this paper, and, to confine the discussion, only the question of hardwood waste will be considered.

In speaking of waste in its strictest meaning, we are considering every part of the original timber that did not go to make up a salable product. Economically, of course, this would not all be considered waste, as part of the timber is necessarily used up in the process of manufacture, although not actually appearing in the salable product.

This economic waste is reduced in modern sawmill practice to a much lower figure than formerly, although it is admitted that there is still room for improvement. Our definition of waste from the viewpoint of the timber owner is then *that which is wasted because it cannot be profitably made into a lumber product.*

Many proposals have been made by the chemical and engineering professions for the utilization of wood waste for one thing or another. Many of these schemes have, unfortunately, lacked the thorough scrutiny they should have had, with result that some perhaps apparently unimportant item was overlooked upon which the success or failure of the whole proposition turned, with failure as a result in most cases.

The case of one large lumber company may be mentioned which had such a proposition put to it—one of those schemes by which the sawdust, shavings, and other small waste, "which cost them absolutely nothing," were to be turned into a handsome profit. The process involved complicated apparatus, which worked beautifully in the experimental plant, where the demonstrator made a test once in so often. When the process was applied on a large scale, it was found that the small repairs which the experimental apparatus underwent after each run were actually duplicated on the large scale, only, of course, multiplied, so that in fact two consecutive runs were never made with the apparatus, and after several months the whole plant was sent to the junk pile. That is only one instance, but it is just such propositions that have made the lumbermen think twice before venturing into this new field. The trouble is that waste material is something quite tangible, while the labor and cost of turning that waste into a salable product is quite intangible, with the result that the saving of the original waste is often accomplished at the expense of another even greater waste.

The object of this paper is not to present any untried proposals, but to discuss as briefly as possible how this proposition of waste material has been studied from a practical standpoint and to show how the problem has been partially solved.

In studying the actual waste from hardwood lumbering operations, this waste naturally divides itself into two classes:

1. The waste of small and low-grade timber left standing in the forest and the waste in cutting down the trees in the forest.
2. The waste at the mill in cutting the log into lumber.

It is quite possible that the forester will not agree to classifying small live timber, that might in the future make merchantable timber, as waste. However, it must be admitted that the mill-owner operating on a comparatively small tract as regards the time necessary to clear it cannot afford to go back later after these trees have matured, at least with present methods of clean cutting, and much of this small timber, therefore, properly comes under our definition of waste. Just what the limits for cutting are depend so largely on the actual mill costs that each operator will probably have to make his own estimates.

An interesting experiment along this line was made by the Goodman Lumber Company, Goodman, Wis. Mr. R. B. Goodman, of that company, in discussing the wood waste in the forest in a paper read before the Northern Hemlock and Hardwood Manufacturers' Association, April, 1913, says:

> "Our specifications for logging birch and maple are 8-inch surface clear for birch and 10-inch surface clear for maple. Since we adopted these specifications the value of birch and maple increased $5 per thousand, and it occurred to me that this advance would enable me to cut my logs on a much harder specification, both as to size and character of the log. We reduced our specifications to 7-inch for birch and 8-inch for maple and included a fairly hard grade or No. 2 log. This difference in specification (1) increased the logging from $1 to $2 per thousand; (2) the smaller and rougher logs decreased the mill cut 20 per cent, with a consequent increase in the cost of sawing; (3) the larger percentage of low-grade lumber decreased the average value of the product of the log, so that by endeavoring to utilize the poorer logs, and thus decrease the waste of materials in the woods, we actually increased the cost of manufacture *more* than $5 per thousand."

Mr. Goodman estimates that with 8-inch and 10-inch specifications for birch and maple, 70 per cent of the weight of material in the forest is left as waste—material from which lumber cannot profitably be made.

From the 30 per cent of the forest which goes into the mill as merchantable logs is obtained the second class of waste. Mill waste is variously estimated, but on the average can be considered as follows:

	Per cent.
Dust	12
Bark	12
Slabs	10
Edges and trimmings	12
Shavings	4
Total waste	50

Of this waste the dust, bark, and shavings, comprising 30 per cent of the log, usually goes for fuel at the sawmill, while the large slabs, edges, and trimmings are used for other purposes.

From these estimates it is seen that practically 80 per cent of the original hardwood forest is waste material, and the proposition is to turn as much as possible of this enormous waste into a profitable product in excess of the labor spent in the manufacture.

Mills located at great distances from the forest have found less opportunity for utilizing the largest portion of this waste—that left in the forest—than the mill located in the timber region. However, the mills farthest from the timber are usually in the city, where the value of the mill waste for fuel is high, and in a number of cases of that kind no further solution of the waste problem has been sought.

For example, at Wausau, Wis., practically 100 miles from the forest, slabs and other large waste bring $1.75 per cord at the mill, and in addition the small waste sells for 60 cents a ton. Practically the entire mill waste is thus disposed of for domestic fuel purposes.

With the mill in the heart of the timber the proposition is quite different, and the solution of this problem, which has been employed successfully, is that of using a large proportion of both mill and forest waste as raw material for destructive distillation.

The destructive distillation of hardwoods for the manufacture of wood alcohol, acetate of lime, and charcoal has been a well-established industry in this country for a number of years.

Principally birch, maple, and beech have been used for this purpose, and until recent years the disposition to use anything but the best timber has not been very great. However, with the increase in the value of merchantable timber the tendency to utilize material unfit for lumber has increased. Recent experiments at the Forest Products Laboratory have shown that slabs and limb wood of several species are equally as good, and even better in some cases, than sound heartwood. The sawmill combined with the distillation plant has been attempted but recently and the combination affords a new source of raw material for the distillation industry, and is at the same time an opportunity for the mill-owner to turn some of his waste into a profit.

Of the wastes we have been discussing, that which has been found most suitable for distillation is:

1. From the forest:
    - *a.* The small trees under the 8 by 10 inch specifications down to 5-inch minimum in diameter.
    - *b.* The larger and straighter of the limbs.
2. From the mill:
    - *a.* The slabs.
    - *b.* The large edges and trimmings.

Usually there is a surplus of shavings, dust, bark, and other small waste above that necessary for fuel to run the sawmill, and this is used for fuel to fire the retorts and for steam to run the various refining operations in the production of alcohol and acetate of lime. All of the logging and mill waste is then utilized excepting the stumps, most of the tops, and all saplings under 5 inches in diameter.

If it is assumed that the poorer trees between 5 inches and 8 to 10 inches and the large limbs equal 20 per cent (a low estimate) of the weight of the forest after the trees of merchantable size have been removed, and if the estimate that the total forest waste equals 70 per cent of the original is correct, there is available from these poorer trees for distillation purposes:

$$20 \times 70 = 14 \text{ per cent of the original forest.}$$

In addition there are the slabs and large edgings, which equal about 16 per cent of the merchantable log, and if these logs equal 30 per cent of the original forest

$$16 \times 30 = 5 \text{ per cent of the original stand in this form.}$$

It will be seen from these calculations that no less than 20 per cent of the forest is suitable for distillation, and as only 20 per cent of this same forest is made into lumber, in this way twice as much of the timber is being turned into marketable products as formerly.

The total amount of hardwood used by the distillation industry amounted to a little over a million cords in 1911, 90 per cent of which was supplied by four States—Michigan, Pennsylvania, New York, and Wisconsin—this amount being distributed as follows:

	Per cent.
Michigan	37
Pennsylvania	35
New York	12
Wisconsin	6
Total	90

The total cut of maple, beech, and birch in 1911 was practically 1,800,000,000 feet, 66 per cent of which was cut in the four principal distillation States.

Again, if for every thousand feet of lumber at least a cord of waste wood is available, it takes very little imagination to see that practically all of the million cords of wood used for distillation purposes could be supplied in connection with sawmill operations, provided that a fair proportion of the enormous cut of maple, birch, and beech is produced by a small number of mills with a large output.

The lumbermen who are now utilizing their waste material have realized what every lumberman must realize in the near future: That with the gradual and continued rise in stumpage prices and the uncertainty of lumber keeping even pace with this rise they cannot put all the burden on the lumber and are endeavoring to make the waste help bear the load. To illustrate the effect of this closer utilization on (1) the value of the stumpage and (2) on the profits from a given area, let us assume an operation on 100,000 acres of hardwood. This area will average 5,000 feet b. m. of merchantable timber per acre, with a stumpage value of approximately $5 per thousand. The value of the saw timber per acre is then $25. In addition, according to the estimates, there is at least one cord of distillation wood for every thousand feet of lumber. If the stumpage value of distillation wood is $1 per cord, or $5 per acre, which is a very reasonable figure, the total stumpage value is $30 instead of $25, or an increase of 20 per cent, and this increase in the value of the stumpage is due wholly to the value which has been created by a demand for the forest waste as chemical wood.

The cost of manufacturing hardwood lumber is approximately $8 per thousand, or $13, including the stumpage price. The lumber has an average value of $16, netting a profit of $3 per thousand feet, or $15 per acre. The cost of preparing the distillation wood for logging and splitting is about $1.75 per cord, the total cost of this wood being $2.75, including the stumpage value. The chemical wood brings on an average $3.50 per cord, thereby netting a profit of 75 cents per cord, or $3.75 per acre, so that when the inferior wood is utilized the profit per acre is $18.75 instead of $15—an increase of 25 per cent.

A condition has thus been realized that is an important factor in encouraging the growing of timber. The stumpage value has been increased without increasing the price of lumber, due, of course, to the fact that the chemical wood is made to realize a profit to balance the increase in the cost of hardwood lumbering operations caused by this increase in value of the timber on a given area.

In preparing this poorer wood for the distillation plant several methods are used. The specifications are fairly rigid. The wood must be in 4-foot lengths, not exceeding 6 inches in thickness and seasoned for at least one year in open piles. In some localities it is found difficult to get enough expert wood-choppers to prepare the distillation wood in the forest. Cutting and seasoning in the woods necessitates the expense of leaving the logging spurs for a year after taking out the merchantable logs, besides the additional fire risk. Some plants, however, prefer to cut in the forest and then haul to the plant to season, this being the usual practice where plants are operated independently of sawmills. The most recent mills to adopt the chemical utilization of forest and mill waste have found it advantageous to prepare all the chemical wood right at the mill. All chemical logs are cut along with the trees suitable for timber and are brought to the mill together and sorted. A small mill is provided especially for the chemical logs, where they are cut into 4-foot lengths and split to suitable sizes. This chemical wood, together with the slabs and large edgings, is then conveyed to the yard of the distillation plant and piled for seasoning.

The distillation wood either is furnished at cost to the distillation plant, if the wood mill and chemical plant are the same organization, or is supplied at a figure that will insure a fair return on the wood mill, boiler, and chemical plant investment, as in the case of a mill which has joined forces with an independent distillation company on an equal investment basis. In this second case it is stipulated that the price of the wood will fluctuate with the market price of the distillate products in order to insure an equalization of the profit. As the sawmill owns and operates the boilers that furnish steam for the refining operations and also supplies the small waste as fuel to distill the wood, an additional charge is made against the distillation company for this service. About $1 per cord of wood distilled is considered a fair price for these fuel requirements. The chemical wood brings the sawmill from $2.50 to $4 per cord, depending on the value of the charcoal, acetate, and alcohol produced, which during the past eight years has varied between $6 and $11 per cord.

Three general types of apparatus are used in this country for the destructive distillation of hardwoods:

1. In Pennsylvania and New York the usual type is a small cylindrical retort holding approximately one cord.
2. In Michigan and Wisconsin is seen either the large beehive brick-kiln, the type most commonly used where charcoal is the chief product desired, in which 50 to 90 cords are distilled, or
3. The rectangular oven, holding about eight cords, in which the wood is loaded on cars and run into the distilling apparatus. This latter type has proved to be most economical, especially as regards the cost of handling the wood and charcoal, and is probably about the best adapted to the utilization under discussion.

The minimum size of this type of plant for profitable operation is about six ovens, or a capacity of 48 cords every 24 hours. The equipment of a distillation plant of this size, including the boiler and wood mill, costs approximately $175,000. A switch-engine is necessary to haul the wood from the mill to the chemical yard and for loading and unloading the retort cars. There is also required a large supply of running water. About 20 men are employed for handling the wood and products about the plant and to fire the ovens, besides a superintendent, his assistant, and a yard foreman. In all, the total laboring force to operate the plant, including those required in the woods and the wood mill, is about 90 men.

In considering practicable methods of utilization and not simply a *possible* solution of the problem, it is necessary to mention that the combination of the sawmill and distillation plant has several limitations both as to actual operation and future possibilities. Briefly, these are:

1. *From the Viewpoint of the Sawmill*

A plant of 48 cords per day capacity requires the mill and forest waste of a lumber mill of at least 10,000,000 feet output per year of maple, birch, beech, or other similar hardwood which give comparable yields of distillation products. This solution of the waste problem is, therefore, limited to fairly large mills, although a group of smaller mills in the same locality could probably avail themselves of similar advantages.

As the cost of installation and the depreciation on the apparatus is high, especially for the ovens, the minimum raw material necessary in order to realize on the investment and to be able to abandon the plant with a fair profit at the end of the lumber operations is about a 20-years' supply.

In the actual cases which have been used as the general basis of this discussion these requirements have been met, and with careful management at least 6 to 8 per cent has been shown to be realizable on what was formerly wasted in the woods and in the mill, and these mill-owners have the keen satisfaction of being able to utilize practically twice as much of their hardwood stumpage as when they were making lumber the only forest product.

2. *From the Standpoint of the Distillation Plant*

The foremost consideration for the chemical plant is the assurance of a steady market for the products. The most difficult product to market is the charcoal. Its value is not very high and its bulk is so great that it is impracticable to ship it great distances. The largest use of charcoal is for the manufacture of charcoal pig-iron, and it is, fortunately, the case that the hardwood timber of the most important distillation State is also closely accessible to the great iron-ore deposits. So in this region the charcoal blast furnace is frequently operated by the distillation plant, domestic markets being very limited at present in these localities. In the eastern distillation States excellent markets exist for charcoal as domestic fuel.

Acetate of lime and wood alcohol are fairly stable products and are as a rule easily marketable. Much fear has existed among the wood-alcohol manufacturers that the increased use of industrial or denatured grain alcohol will eventually seriously affect their market. However, as the production of grain alcohol is about 40,000,000 gallons per year and that of wood alcohol less than 10,000,000 gallons, it appears fairly certain that an increase in the amount of denatured alcohol used, in which wood spirit is used as a denaturant, will serve to stimulate rather than retard the production of wood alcohol.

One other situation should be mentioned which the lumberman venturing into the chemical utilization of wood waste would probably have to consider. At present both the price and production of acetate of lime and wood alcohol is controlled to a large extent by eastern capital. While in general the products of a chemical plant would have to be marketed through this combine, it may be said that as one of the largest distillation plants in the country has successfully broken away from this controlling agency, it is probable that the condition is not as serious as might be supposed.

These limitations must be squarely met by the lumberman interested in this method of utilization, but it is believed the risk to be taken is no greater than that in erecting a sawmill with the possibility of wide fluctuation in lumber prices.

A practical solution of the problem of making greater use of hardwood stumpage, thereby increasing its value, has been outlined and the discussion resolves itself into the following most essential considerations:

1. A careful study of waste available and best methods of handling this wood from the forest to the mill, to the plant.
2. A large mill cutting at least 10,000,000 feet per year, with a supply to last 20 years.
3. A destructive distillation plant in conjunction with the sawmill.
4. An assurance of a steady market for the products of the chemical plant.

By this method of utilization it has been further shown that practically twice as much timber can be cut from a given tract as when cutting only for the production of lumber products.

CLIMATIC CHARACTERISTICS OF FOREST TYPES IN THE CENTRAL ROCKY MOUNTAINS

Fremont and Wagon Wheel Gap Experiment Stations

BY C. G. BATES, F. B. NOTESTEIN, AND PETER KEPLINGER

Contributed

OBJECT

The purpose of this experiment is to compare the climatic characteristics of the various types which occur in two localities of southeastern and southwestern Colorado for a short term of years, and to compare the characteristics of similar types in the two localities for a long term of years. This arrangement is founded on the fact that in any single locality differences in climate are constant, hence it is only necessary in considering the types of one locality to measure conditions for one or two years. On the other hand, two localities may vary widely in climate in any one year and they must be compared for a number of years in order to determine their mean differences.

LOCATION

The study has been carried on at the Fremont and Wagon Wheel Gap Experiment stations. At the Fremont station three situations for study were selected and observations were begun on them in March, 1910. These three situations, which represent three types produced at practically the same elevation, 8,850 feet, by differences in aspect, were studied for two full years, or until the end of February, 1912, since which time observations have been continued only at the intermediate or control station.

At the Wagon Wheel Gap station observations on the climate of four different situations have been in progress since March, 1911. These situations represent different types produced by different aspects and will, as at the Fremont station, be directly compared for at least two years, after which observations will continue at the control station, which is very similar to the control station at the Fremont Experiment Station. As a matter of fact most of the data secured at Wagon Wheel Gap are a necessary part of the stream-flow experiment and will be available for use in these climatic comparisons for a number of years.

The principal data given here are those covering the three types at the Fremont station for a period of two years. In cases where they appear valuable, the data for the four types at the Wagon Wheel Gap station for the year 1911 are compared with the data from the Fremont station for the same period. However, as above stated, these comparisons of two different localities are not of much value until data have been obtained to cover a number of years.

The years in both cases begin with March 1 and terminate with the last day of February and, according to the usual custom in considering meteorological data, the spring season is considered as beginning March 1, the summer season June 1, the fall season September 1, and the winter season December 1.

The three situations at the Fremont station may be described as follows:

(1) The yellow-pine type as it occurs on a south slope of about 20 per cent gradient. A stand of about 30 mature trees per acre surrounds the observation point.

(2) The yellow pine-Douglas fir type (described in the tables as the "pine-fir" type) as it occurs on a low ridge of easterly bearing which lies between the pine type already described and the spruce-fir type described in the next paragraph. On this situation is located the control station. The observation point is not immediately surrounded by timber. However, on this ridge occur yellow pine, blue spruce, and aspen, and these indicate that the conditions are intermediate between those of the yellow-pine and Douglas-fir types proper.

(3) The Engelmann spruce-Douglas fir type (described in the tables as the "spruce-fir" type) as it occurs at the foot of the north slope of about 40 per cent gradient. The observation point is immediately surrounded by a dense stand of young Engelmann spruce about 35 feet high. However, immediately above the observation point, Douglas fir is found mixed with the spruce and the slope may only be considered typical spruce ground at its extreme lower edge where moisture is especially abundant. Therefore, it is considered that the observation point represents an intermediate stage between the Douglas fir and Engelmann spruce types.

METHODS

At each of these three points, observations of atmospheric conditions have been made on towers 20 feet above the ground where it was expected to measure the mean conditions affecting the life of the tree.

In addition to the above stations regularly studied at the Fremont station, there have been used data on temperature and precipitation from a regular Weather Bureau station (Lake Moraine), situated close to the Fremont station at an elevation of 10,250 feet. This site is described under the data for the Fremont station, as the "spruce type." The situation is on an easterly slope of about 10 per cent gradient and the observations are taken at an elevation of about 4 feet above the ground. The observation point is not immediately surrounded by timber, but a spruce forest occurs on the same slopes within a few rods of this point.

The observations at the Wagon Wheel Gap Experiment Station have been taken on towers about 8 feet above the ground in sites which may be described as follows:

(1) The yellow pine-Douglas fir type (described in the tables as the "pine-fir" type) as it occurs on an easterly slope of about 20 per cent gradient. There is no timber except aspen immediately surrounding the observation point. The point appears to be about at the line of cleavage between yellow pine and Douglas fir, since these species occur below and above the point, respectively. The elevation of this point is about 9,300 feet.

(2) The Douglas fir, south slope type (described in the tables as the "fir, south" type) as it occurs on a southerly slope of about 30 per cent gradient. The observation point is immediately surrounded by an open stand of mature and immature Douglas fir probably representing the optimum forest conditions for south slopes in this locality. The elevation of this point is about 9,500 feet.

(3) The Douglas fir, north slope type (described in the tables as "fir, north" type) as it occurs on a northerly slope of about 30 per cent gradient. The observation point is immediately surrounded by a close stand of young Douglas fir about 40 feet high. The rain gauge and anemometer, however, are in a small opening several rods distant.

(4) The Engelmann spruce type as it occurs on a practically level area at 11,000 feet elevation. The observation point is not in the forest but in the middle of a burn of several acres extent, with no living trees immediately surrounding it. The burned trees, both standing and down, tend to relieve the exposure very slightly.

The data are taken up in order under the following headings:

A. Air temperatures.
B. Atmospheric humidity.
C. Wind movement.

D. Barometric pressure.
E. Precipitation.
F. Sunshine.
G. Soil temperatures.
H. Soil moisture.

A. *Air Temperatures*

Mean temperatures.—The mean air temperatures of the types are obtained by averaging the maximum and minimum temperatures for each day. This method is a generally accepted one and usually gives a figure within 1 degree of the absolute mean temperature from hourly readings.

The mean temperatures of the types at the Fremont station for two years are shown in Table 1, by months and seasons.

TABLE 1.—*Mean air temperatures of types, by months, Fremont station, 2 years*

Season and month.	Type.			
	Pine.	Pine-fir.	Spruce-fir.	Spruce.
	°*F.*	°*F.*	°*F.*	°*F.*
March	37.40	35.50	35.52	30.85
April	39.15	37.73	37.76	33.60
May	46.40	44.70	[1] 46.90	41.60
Spring	41.02	39.32	40.06	35.35
June	58.60	56.80	55.20	51.70
July	59.64	58.55	58.32	53.70
August	59.21	57.72	58.20	52.60
Summer	59.20	57.70	58.43	52.67
September	55.62	54.20	53.82	50.40
October	42.72	40.70	40.17	38.20
November	33.32	32.42	31.30	27.80
Fall	43.90	42.41	41.76	38.80
December	25.40	24.20	22.65	19.95
January	29.60	28.70	27.64	24.70
February	23.20	21.50	21.10	18.75
Winter	25.98	24.64	23.61	21.13
Year	42.52	41.06	40.72	36.98

[1] Records for May, 1910, are missing.

For comparing the types at the Fremont and Wagon Wheel Gap stations, only the data for 1911 are available. The seasonal mean air temperatures for the two localities are given in Table 2.

TABLE 2.—*Mean air temperatures of types, by seasons, 1911, Fremont and Wagon Wheel Gap*

Station and type.	Mean air temperatures.				
	Spring.	Summer.	Fall.	Winter.	Year.
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
Fremont:					
Pine	39.83	58.37	41.33	23.87	42.52
Pine-fir	38.42	56.38	39.61	21.95	41.06
Spruce-fir	38.69	56.08	39.06	21.06	40.72
Spruce	35.53	52.47	36.87	18.27	36.98
Wagon Wheel Gap:					
Pine-fir	36.60	53.10	36.80	16.30	35.70
Fir, south	36.80	53.00	37.00	17.10	35.98
Fir, north	35.10	52.40	34.70	14.70	34.22
Spruce	31.60	49.00	33.50	16.10	32.55

Tables 1 and 2 indicate that the pine and pine-fir types at the Fremont station are constantly warmer than the spruce-fir and spruce types. While, averaging the two years, the greatest difference in the types occurs in the winter, in 1910 the greatest difference occurred in the spring, and in 1911 the least difference occurred in the spring. All in all, it would appear that the difference is likely to be about constant for the various months, through a term of years.

In only one case, in the year 1911, was the spruce type warmer than the pine-fir type similarly exposed. This was in January, the coldest month at the Wagon Wheel Gap station, while for the winter season as a whole the spruce type averaged 0.2 degree cooler than the pine-fir. However, it is noteworthy that at Wagon Wheel Gap the spruce type, exposed and on a gentle easterly slope, was warmer than the Douglas fir type on north slope throughout the winter season.

It is apparent that differences in aspect may make slight differences in air temperatures. At the Fremont station the difference of 1.8 degrees between south and north slopes is accompanied by a change from the pine to the spruce-fir type, while at Wagon Wheel Gap a difference of 1.8 degrees is not accompanied by a change in the type species. It would appear from this that differences in air temperatures do not necessarily distinguish the types. In the year 1911 the spruce type at the Fremont station, 10,250 feet elevation, was warmer than the pine-fir type at the Wagon Wheel Gap station, at 9,300 feet elevation.

Mean daily range of temperatures.—It is possible that, even with practically the same mean temperatures, the mean daily range of temperatures (difference between highest and lowest for each day) may vary greatly. The mean daily range is likely to be greatly affected by local factors, such as exposure to insolation, stagnation, or poor air drainage, and the presence or absence of forest cover. On the other hand, between two near-by points, the relation should be practically constant for the same period in successive years. This is shown to be the case by the two years' records at the Fremont station. Hence, only the records for 1911 need be given to demonstrate the difference between types, and for the sake of brevity these data are summarized by seasons.

TABLE 3.—*Mean daily range of temperatures, by seasons, 1911, Fremont and Wagon Wheel Gap stations*

Station and type.	Mean daily range of temperatures.			
	Spring.	Summer.	Fall.	Winter.
	°F.	°F.	°F.	°F.
Fremont:				
Pine	20.18	19.41	21.28	18.64
Pine-fir	21.72	22.89	23.23	21.39
Spruce-fir	23.92	24.44	23.60	20.30
Wagon Wheel Gap:				
Pine-fir	23.57	25.43	24.57	25.00
Fir, south	24.00	26.23	25.13	24.70
Fir, north	21.83	24.50	20.60	20.13
Spruce	18.63	17.87	18.27	17.04

From Table 3 it is evident that a constantly greater or less range of air temperatures cannot account for the formation of a particular type stand. At the Fremont station the greatest range of temperatures occurs in the spruce-fir type except in winter, when this site receives very little insolation, and even then the range is greater than in the well-drained pine type. On the other hand, the spruce type at Wagon Wheel Gap has the lowest daily range, being a well-drained site, and the north slope fir type has also a very low range of temperatures, corresponding to the spruce-fir at the Fremont station. Considering all the data shown above, it appears that the daily range of temperatures is dependent on local combinations of insolation and air drainage which may or may not accord with type formations. Rather is the range of temperatures dependent upon the presence of timber than the cause of its presence.

Total range of temperatures.—The total range of temperatures for the year is distinctly a local feature of climate; hence it is impossible to compare the types at the two stations on the basis of the meager data available. However, the extremes of temperature for 1910-11 at the

Fremont station and for 1911 at Wagon Wheel Gap are given in order that the types may be compared.

TABLE 4.—*Extremes of temperature and total range*

Station and type.	1911.			1910.		
	Maximum temperature.	Minimum temperature.	Total range.	Maximum temperature.	Minimum temperature.	Total range.
	°F.	°F.	°F.	°F.	°F.	°F.
Fremont:						
Pine	82.0	— 4.5	86.5	84.0	—19.0	103.0
Pine-fir	78.0	— 7.0	85.0	84.0	—22.5	106.5
Spruce-fir	80.0	— 8.0	88.0	82.0	—22.5	104.5
Spruce	75.0	—18.0	93.0	75.0	—28.0	103.0
Wagon Wheel Gap:						
Pine-fir	77.3	—19.0	96.3	......	......	.....
Fir, south	77.2	—17.2	94.4	......	......	.....
Fir, north	75.0	—17.0	92.0	......	......	.....
Spruce	68.6	—13.0	81.6	......	......	.....

It does not appear that there is any constant relation between the total range of temperatures in the different types. In 1911, at the Fremont station, the spruce and spruce-fir types showed the greatest range, while at Wagon Wheel Gap exactly the opposite was true.

It seems likely that, conditions of cover being equal, the spruce type will have the lowest total range because it is usually best drained. But either the highest or lowest extreme of temperature may come in a calm period and upset this relation. This factor may, therefore, be dismissed as unimportant.

In general it may be said that air temperatures are not good criteria of the qualities of a site. Air moves about freely, and its temperature is only slightly affected by contact with the earth, snow, tree trunks, etc., which are radiating or absorbing heat. Consequently, granting that heat is important, it is believed, to find an explanation for the presence of trees on a certain site, other factors which are the direct causes of certain air temperatures must be measured.

B. *Atmospheric Humidity*

In considering the possible effect of atmospheric humidity on plant life, it is best to use a measure of humidity which expresses the evaporative power of the air. This is best found in the "vapor deficit," a figure, in inches of mercury pressure, which indicates the difference between the weight of the aqueous vapor actually in the air and that which the air at the existing temperature is capable of holding.

The vapor deficit for all the types has been measured only at 7 a. m., and this is so directly dependent upon the exposure of the observation point to isolation at that particular time that the figures are not of great value. However, the mean figures for the two years for all types at the Fremont station are given in Table 5.

TABLE 5.—*Mean vapor deficit, Fremont station, 2 years*

[Vapor deficit in inches of mercury]

Month.	Type.		
	Pine.	Pine fir.	Spruce-fir.
March	0.114	0.098	0.099
April	.111	.109	.092
May	.170	.170	.180
June	.282	.287	.339
July	.267	.265	.288
August	.259	.254	.287
September	.200	.193	.208
October	.160	.131	.244
November	.107	.095	.098
December	.072	.055	.049
January	.107	.094	.089
February	.065	.057	.053
Year	.159	.146	.169

In Table 6 the mean vapor deficit as obtained from observations at 7 a. m., 1 p. m., and 7 p. m. is given for a site at each station from the data for 1911.

TABLE 6.—*Mean vapor deficit, Fremont and Wagon Wheel Gap stations, 1911*

[Vapor deficit in inches of mercury]

Month.	Station and type.	
	Fremont, pine-fir.	Wagon Wheel Gap, fir-north
March	0.104	0.067
April	.111	.107
May	.204	.195
June	.325	.233
July	.159	.146
August	.243	.161
September	.211	.141
October	0.092	0.094
November	.087	.047
December	.056	.024
January	.112	.038
February	.060	.044
Year	.147	.108

The comparison of the three types given in Table 5 means very little, since the humidity at 7 a. m. may or may not be near the mean for the whole day. However, on the basis of three daily readings during July, 1911, it was established that, while the mean vapor deficit of the spruce-fir type is not so great as indicated by Table 5, it is actually greater than in the pine-fir type. The mean humidity on 7 a. m., 1 p. m., and 7 p. m. readings was in July, 1911:

	Pine type.	Pine-fir type.	Spruce-fir type.
7 a. m.	0.190	0.187	0.199
1 p. m.	.199	.193	.203
7 p. m.	.116	.097	.098
Mean	.155	.143	.149

On these data it is found that with the same temperatures the vapor deficit in the spruce-fir type is greater than in the other types. This is a very surprising fact when the density of the spruce-fir stand and the amount of transpiration going on therein are considered.

The comparison of rather similar types at Fremont and Wagon Wheel Gap given in Table 6 seems to indicate that the vapor deficit is less in the dense north-slope stand at the latter place. However, this comparison, covering only one year, must be considered in connection with the fact that the Wagon Wheel Gap site had at least 20 per cent more rain during the year than the site at Fremont.

On the whole it must be admitted that the observations so far have not indicated any consistent differences between the types in the matter of atmospheric humidity. Atmospheric moisture, like atmospheric heat, is readily diffused, so that adjacent sites are likely to be very similar.

C. *Wind Movement*

Excessive wind movement may not only be important in limiting the distribution of a species by causing excessive evaporation, but it also plays an important part in the distribution of heat. The following data for the year 1911 seem to indicate that under normal conditions the wind movement in the central Rocky Mountains is so light as to be an unimportant factor in evaporation.

TABLE 7.—*Wind movement in various types, Fremont and Wagon Wheel Gap, by seasons, 1911*

Station and type.	Average wind movement per hour.				
	Spring.	Summer.	Fall.	Winter.	Year.
Fremont:	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*
Pine	5.27	3.45	4.38	5.05	4.54
Pine-fir	6.11	4.30	6.82	5.61	5.71
Spruce-fir	2.68	1.65	2.25	2.53	2.27
Wagon Wheel Gap:					
Pine-fir	4.29	3.43	3.35	2.93	3.50
Fir, north	1.14	1.07	.77	1.00	1.00

At Fremont in 1910 the types gave: Pine 4.54, pine-fir 5.31, and spruce-fir 2.36 miles per hour, indicating the constancy of the relation between the types.

The difference in 1911 between the corresponding pine-fir types at the two stations was greater than the difference between the pine-fir and pine types at the Fremont station and almost as great as the difference between pine-fir and spruce-fir. The local differences, however, are directly chargeable to differences in the immediate surroundings of the instruments. When it is considered that toward the eastern limit of yellow pine this species tolerates an average wind velocity of 10 miles per hour and that spruce near its alpine limits is sometimes subjected to an almost constant gale, the insignificance of the factor of wind movement in this study is readily seen.

At both stations the wind has been shown to rise and fall daily with the rises and falls of temperature. Thus the greatest wind movement is nearly always at midday.

D. *Barometric Pressure*

The barometric pressure, of course, decreases with altitude, and hence is lowest in the spruce and highest in the pine type. Differences for types might be calculated very accurately from tables.

As in the high-plateau region in general, the highest readings at both stations were recorded in July and August. The annual range from monthly means was, at the Fremont station in 1910, 0.37 inches and at the Wagon Wheel Gap station in 1911, 0.35 inches.

E. *Precipitation*

While for several sites in the same immediate vicinity the total precipitation for a period of years ought to be nearly the same, it is almost impossible to obtain the same catch in two adjacent gauges. Exposure to wind invariably tends to reduce the catch. Hence while the following figures show differences in the precipitation of contiguous sites, the differences in the more widely separated sites are of greatest importance.

TABLE 8.—*Precipitation in various types, Fremont and Wagon Wheel Gap stations, by seasons, 1911*

Station and type.	Precipitation, rain and snow.				
	Spring.	Summer.	Fall.	Winter.	Year.
Fremont:	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Pine	4.43	9.22	3.13	2.17	18.95
Pine-fir	4.90	8.64	3.50	2.31	19.25
Spruce-fir	4.80	9.52	3.41	2.39	20.12
Spruce	6.35	12.73	3.82	2.48	25.38
Wagon Wheel Gap:					
Pine-fir	2.58	9.39	6.89	1.78	20.64
Fir, north	2.87	9.46	8.09	2.29	22.71
Spruce	3.32	10.48	8.67	2.05	24.52

From Table 8 it would appear that at both stations there is a gradual increase in precipitation from the pine to the spruce types. It is difficult to account for the excess obtained in the pine-fir type over the pine type at the Fremont station, since the observation point in the former is at slightly lower elevation, is more exposed, and shows constantly higher wind velocities. It is possible that the topography actually causes slightly greater precipitation in the pine-fir, as this excess has been maintained two successive years.

At the Fremont station a difference in elevation of 1,400 feet between the pine-fir and spruce type causes a difference in precipitation of 6.4 inches. At Wagon Wheel Gap a difference of 1,700 feet causes an excess of 3.9 inches in the spruce type. In the first case the sites are 3 miles apart, in the second 1½ miles.

Especially noteworthy is the fact that the main excess of precipitation in the spruce type at both stations occurs in the spring and summer. In these localities the bulk of the spring precipitation is in the form of snow, or it may be snow at the higher situation and rain at the lower. Hence the longer retention of snow in the spruce type at the higher elevation is not necessarily the result of much lower air temperatures or less insolation, but of the fact that more snow falls there than at lower elevations. On the other hand, when the spruce type is found at the same elevation as the pine or fir types and its snow is retained longer in the spring the difference must be accounted for by difference in insolation (as the result of different aspect) and not by difference in quantity.

Table 9 shows the mean snow depth in various types at both stations for the winter of 1910-11.

TABLE 9.—*Mean depth of snow on ground*

Station and type.	Mean snow depth.						
	November.	December.	January.	February.	March.	April.	May.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Fremont:							
Pine	0.2	0.5	0.1	3.5	1.6	0.6	.....
Pine-fir	.2	.6	.1	3.5	1.1	.6	.....
Spruce-fir	.5	1.5	.6	3.0	6.2	1.7	.....
Wagon Wheel Gap:							
Pine-fir	4.1	10.4	20.0	20.3	26.1	9.2	.....
Fir, south	.6	4.2	5.0	.9	8.8	.1	.....
Fir, north	13.4	17.1	23.5	21.2	36.4	28.4	3.4
Spruce	11.8	16.9	24.6	24.5	44.5	36.3	13.8

It is to be noted that in the month of April, for example, the pine-fir types at both stations have much less snow than the fir-north, spruce-fir, and pure spruce types. Up to February the differences are not great because a large proportion of the snow has been retained on all types, except where directly insolated by the low winter sun, and what melting occurs is largely from ground radiation, which may be just as great or even greater under a dense north slope stand than under an open stand on south slope or flat.

The difference between the north slope and south slope fir types at Wagon Wheel Gap is very marked, indicating that the Douglas fir may tolerate a wide range of conditions. The great difference in amount of snow between the two stations is also noteworthy, and indicates that it is the mere presence of snow on the ground, rather than its amount, which is the controlling factor. This is easily understood when it is stated that observations at Wagon Wheel Gap in 1911 showed that the soil temperature stood at 32° F. from the time snow began melting until it was entirely gone. The quantity of snow, therefore, is unimportant; the time of retention is all-important.

F. *Sunshine*

Measurements of the actual sunshine in the various types have not been made at either station. Measurements at the control stations (pine-fir types) show that at the Fremont station fall is the season of least sunshine, while at Wagon Wheel Gap, at least in 1911, summer has by far the lowest percentage. Winter and spring in both places have high percentages.

General observation has shown that the spruce-fir type at Fremont and the north-slope fir type at Wagon Wheel Gap receive practically no direct sunlight during the winter season. Aside from this there can be little difference in the types except as local topographic features may cut off a portion of the early morning and late afternoon sun.

The further investigation of this factor is undoubtedly important, since the amount of insolation of the various types varies greatly. This should not be done, however, with the electric sunshine recorder, but rather with the photometer or by angular measurements and mathematical calculations, so that the angle of incident of the sun's rays on the ground is considered.

G. *Soil Temperature*

The measurement of soil temperatures is undoubtedly about the most important phase of this experiment. Soil temperatures may be said to represent the summation of all of the heat factors of the site, combining the effects of direct insolation and radiation, cooling by the retention of snow, and warming or cooling by the passage of air currents and the evaporation of moisture. Hence the soil temperature of the site should be a direct criterion of the heat requirements of the species.

Soil temperatures at depths of 1 and 2 feet have been taken at the Fremont station for two years. The average results are shown in Table 10.

TABLE 10.—*Mean soil temperatures at depths of 1 and 2 feet, by months, Fremont station, average of two years*

Month.	1 foot.			2 feet.		
	Pine.	Pine fir.	Spruce-fir.	Pine.	Pine-fir.	Spruce-fir.
	°F.	°F.	°F.	°F.	°F.	°F.
March	38.25	34.62	30.40	38.60	35.81	31.14
April	41.58	39.72	32.00	42.81	41.14	32.65
May	47.52	46.42	36.90	48.35	47.21	36.35
June	58.90	57.54	47.37	58.66	57.64	45.26
July	58.51	57.83	50.62	59.47	59.29	49.24
August	57.53	57.89	49.96	59.40	59.08	49.88
September	58.07	55.49	46.29	59.60	58.16	47.45
October	49.01	46.25	39.05	52.77	51.30	41.21
November	39.04	36.62	32.29	42.46	41.46	34.55
December	31.42	30.34	28.12	35.39	34.77	30.65
January	30.65	28.76	26.30	32.24	31.72	28.47
February	32.67	30.44	26.14	34.59	33.32	28.21
Year	45.26	43.49	37.12	47.03	45.90	37.92

It is to be noted that the soil temperature of the pine type is practically always higher than that of the pine-fir, and that of the pine-fir higher than that of the spruce-fir type.

The difference in temperature between the 1-foot and 2-foot depths is not great. It has been shown that the 7 a. m. readings on which these monthly means are based represent about the minimum daily soil temperature at 1-foot depth, and the maximum daily temperature at 2-foot depth. Consequently, while the readings show it only in the pine and spruce-fir types for a short time in late spring, the general tendency during the period of rising temperatures is for the 2-foot depth to be cooler than the 1-foot, while during the period of declining temperatures the surface is the cooler layer.

While the differences in the soil temperatures of the types are greater than the differences in air temperatures, they do not, from casual observation, appear to be great enough to have much effect on growth. Assuming, however, that the vegetative activity of the different coniferous species is dependent on the same amount of heat, and assuming that the temperature necessary to start vegetative activity is 5° C. or 41° F. (as shown by European experiment to be the case with some plants), it is found that there are very radical differences between the types in the length of the period when a growing temperature prevails. In presenting the data in Table 11 it is assumed that the temperature of the soil at a depth of 1 foot determines the vegetative activity, and the length of the growing season is calculated by determining the number of days during which the soil temperature is above 41° F. The calculation is made by the use of mean soil temperatures for the months, since, especially on a south slope, the temperature may rise above 41° F. several times and drop back again before it finally stays up. The use of means overcomes this difficulty.

While the assumption as to the actual limiting factor in growth may be incorrect, this system at least gives a basis for comparing the types. The comparatively accurate character of the figures is seen from the data which show the number of days between the time when the soil temperature reaches 41° F. and the time when growth of the type species becomes apparent in the swelling of the buds. The minus quantity in the column for spruce indicates that growth was observed before the arbitrary temperature was reached.

TABLE 11.—*Length of growing season, Fremont and Wagon Wheel Gap, 1910 and 1911*

Station and type.	Length of growing season.			Time elapsing between theoretical and actual growth in spring.	
	1910	1911	Average.	1910	1911
Fremont:	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
Pine	239	200	220	3	12
Pine-fir	205	188	196	12	....
Spruce-fir	132	134	133	......	—11
Wagon Wheel Gap:					
Fir, north	......	130	......	......	....

It is apparent from the data given above that there may be great differences in the length of growing season of the types; that closely related types may overlay on one another in their requirements for heat, and that the species which demands the least heat is likely to respond a little more rapidly to a warming up of the soil in the spring than that one which demands the most heat.

It seems quite probable that with conifers some activity continues in the fall as long as soil temperatures permit. On the other hand, the only hardwood present in the region—aspen—has shown that it is not governed by the same rules. Buds have begun to swell long before the soil temperature reached 41° F., and aspen trees have been observed in flower when the ground was covered with 2 or 3 feet of melting snow and when the soil temperature, therefore, was at 32° F.

The close agreement of the single observation at Wagon Wheel Gap with the observations at Fremont indicates that within very narrow ranges the type characteristics of a site may be determined by its soil temperatures. For purposes of comparison, all soil temperature measurements should be made at a depth of 1 foot, which is for all purposes most convenient. The desirability of determining a relationship between length of growing season and current soil temperatures at any time in the season, or between length of growing season and degree of insolation at any time during the season, is apparent, and these matters will be given careful attention in this study.

H. *Soil Moisture*

Quite as striking as the differences in length of growing season are the differences in soil moisture of the three types at the Fremont station. Complete records are available only for 1911, during which season soil moisture was determined weekly during the period in which the soil temperature was above 41° F. In the pine and pine-fir types it was impossible to carry out the original program of obtaining samples at 2 feet on account of shallowness of the soil; hence the deeper samples here were at 1½ feet, while in the spruce-fir type at 2 feet. The shallow samples (1 foot), therefore, give the best basis for comparing the types.

Table 12.—*Soil moisture of the types, Fremont station, by months, from weekly determinations, 1911*

Month.	1 foot.			1½ and 2 feet.		
	Pine.	Pine-fir.	Spruce-fir.	Pine.	Pine-fir.	Spruce-fir.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
April	7.23	8.83	....	4.66	6.01	....
May	4.96	6.87	14.64	4.37	5.35	8.38
June	4.30	5.08	9.92	2.98	2.32	4.62
July	6.88	6.42	12.79	4.91	4.96	6.41
August	4.31	4.95	8.94	3.40	4.24	10.01
September	3.84	4.55	6.78	3.69	5.31	7.60
October	3.59	5.39	8.37	3.94	4.81	7.07
Season...	5.05	6.07	10.30	4.06	4.77	7.15

The above figures are for soils of the same mineral composition in the three types, though the soil of the spruce-fir type has doubtless been made more retentive of moisture by the accumulation of humus. For this reason they may be directly compared, and it is evident that there is in the spruce-fir type twice as much moisture during the growing season as in the pine and one and two-thirds times as much as in the pine-fir type.

The greater soil moisture of the spruce fir is doubtless due largely to the northern aspect of the site, which greatly reduces insolation and causes the snow to remain until late in the spring. A high percentage of soil moisture is a natural result of a cool soil and a short growing season. It may also to some extent be the cause of low soil temperatures, so that the two conditions are always likely to be found together.

While it is shown that with uniform soil conditions amount of moisture may be a criterion of the type, yet it must be admitted that different soils cannot be compared with any degree of accuracy unless their water-retaining capacities are determined by very careful tests. Thus we might find in a yellow-pine forest soils containing higher percentages of moisture than are here shown for spruce, yet, if the soil were fine and heavy little of the moisture would be available for the trees. For this reason soil-moisture determinations are not accurate means for comparing types or determining the suitability of a site for a given species.

CONCLUSIONS

In summarizing it may be said that it has been shown, more or less distinctly:

1. That there are wide differences in the heat requirements of the species and in the temperatures of the types. The types vary somewhat in air temperatures, but much more distinctly in soil temperatures. The length of the growing season as determined from soil temperatures is a fairly accurate basis for determining what tree should be grown on the site. It is possible that after a series of careful observations a rule may be laid down by which the growing season may be determined from a very few soil-temperature measurements, or a direct relationship between the degree of solar radiation at any time and the length of growing season may be established. This last, of course, will simply be a scientific method for "sizing up" the combined effects of slope, aspect, and altitude—a thing which is done roughly by the forester every day.

2. Wind movement and atmospheric humidity are, apparently, not important factors in the normal Rocky Mountain forests. Until the wind velocity and vapor deficit become two or three times as great as any of the mean amounts measured in this study they probably need not be seriously considered, since the coniferous species of the region seem to be well adapted to withstand excessive transpiration. It is worthy of note in this connection that the species most accustomed in its natural habitat to high wind velocities and a dry atmosphere suffers most frequently from the chinook, which represents the extreme of these conditions. This species is yellow pine.

3. The soil moisture of the types varies greatly, the spruce requiring the most and the pine the least soil moisture; but the soil moisture percentage is not a good basis for comparing types except in the same immediate vicinity, where it is known that the physical properties of the soils are uniform.

4. In any locality the spruce type probably always receives a greater amount of precipitation than the pine, and if all sites had the same aspect and gradient the amount of precipitation might determine the type. There are, however, too many influences affecting the final value of precipitation to make this element a safe criterion.

From the above it is readily seen that the measurement of soil temperature affords the simplest means for determining the qualities of the site. In this measurement are involved the effects of the slope and aspect; the direct or indirect solar insolation; the effect of retained snow or precipitation which cool the soil; the effect of wind movement and humidity as they may cause evaporation from the soil, and the effect of wind movement as it may bring heat or cold from areas of different temperature.

WORK OF CALIFORNIA GRAY SQUIRREL ON CONIFER SEED IN THE SOUTHERN SIERRAS

BY SWIFT BERRY

Contributed

In his Natural History, W. T. Hornaday describes the California gray squirrel (*Sciurus griseus*) as follows:

> "The California gray squirrel is the Pacific coast counterpart of the eastern gray squirrel, except that it is larger and its colors are brighter. Its color above is bluish gray and black, and underneath it is pure white. It is the largest squirrel in the far west, its maximum length being 12 plus 10 inches. Its home extends from the State of Washington to southern California, and it is in every way a worthy product of that fertile and healthful region."

It is found well distributed throughout the foothill and lower mountain regions of California and apparently migrates locally as the food supply varies. Instances are rare in which it has been known to hoard a supply of food.

This squirrel is very numerous throughout the yellow and sugar pine regions of the southern Sierras during the summer months, and apparently devotes a large portion of its time to cutting pine cones. In the summer of 1910 it was observed in the act of cutting sugar-pine cones over widely distributed areas within the Sierra and Sequoia National Forests during the first days of June. Since sugar-pine seed does not ripen before the first of September, the squirrels are continuously at work destroying seed for a period of three months before it can possibly mature. Any seed dropped or scattered during this period is yet immature and will not germinate.

Tree seed, especially of the conifers, is not produced every year, but is borne at intervals of three to five years. However, even in most poor seed years there are a few localities where some seed is produced. It is in the years of poor conifer seed crops, when all of the seed is especially valuable, that the ravages of the gray squirrel are most evident. They seem to migrate to all the localities where there is any seed, and begin their work early in the season. The year 1911 was accompanied by a rather poor seed crop of yellow pine throughout the southern Sierras, but enough cones were apparently at hand for collecting in certain localities. There is some doubt as to when the gray squirrels began on the yellow-pine cones, but they were observed busily at work throughout the last two weeks of July and the entire month of August. Individual yellow-pine trees, which had been estimated to produce four sacks of cones during the forepart of July, did not contain a single cone on the 20th of August. The remains of the cones on the ground was indisputable evidence that they had been cut off by squirrels. Examination of cones on near-by trees at this date disclosed that the seed was still milky and would not be ripe for at least 10 days.

The supervisor of the Kern National Forest had planned to collect 500 pounds of yellow-pine seed on Greenhorn Mountain near his summer headquarters. The cones were there early in the season, but the gray squirrels had other plans. On August 20, at least 10 days before the seed actually ripened, the remains of 702 cones were counted where they had been cut and fallen from a yellow-pine tree not quite 24 inches in diameter. Possibly 150 cones were still remaining on the tree. Careful search was made, but no stored seed could be found; but split shells were everywhere, showing that the seed had been eaten as soon as the cones were torn to bits. Several green cones from this tree were examined and the seed was all found to be milky and immature.

Near by, under two yellow pines of 20 and 24 inches in diameter, respectively, standing within 20 feet of each, were the remains of 645 cones. A quarter acre circle was taken, which contained seven yellow pines, averaging 300 cut cones each. From 25 to 30 per cent of the cones originally on the trees were remaining on August 20, but as the squirrels were actively at work few would apparently remain by the time the seed had ripened.

There is no question that the above damage was done by the California gray squirrel. It was the only species of tree squirrel present in any quantity, and was frequently observed busily at work cutting off cone after cone. Sometimes several cones are severed and allowed to fall to the ground, after which the squirrel descends and tears off the cone scales, thus exposing the seed. In other instances the cones are torn to pieces without the squirrel leaving the tree.

It has been estimated that there is an aggregate of nearly two million acres of land in California best suited for growing timber which does not bear timber now. Natural reproduction from seed must be depended upon to stock the greater portion of this area.

Consequently, it is evident that by destroying so large an amount of seed the California gray squirrel is a serious menace to reproduction and hinders the forestation of idle land, which should be stocked with forests and thus be producing a return. Another point that should not be overlooked is that the seed of sugar pine and yellow pine is the most frequently eaten, and that seed of inferior species like fir and cedar is not touched when the others can be found. Thus when the gray squirrel does not retard reproduction, its work causes the reproduction to consist mostly of the less valuable species.

The present game laws of California provide that, except in Mendocino County, tree squirrels will not be killed during the period from January to August, inclusive, and that one person may kill but twelve during the open season. On the other hand, bounties are paid for the scalps of natural enemies of the squirrels, and squirrels are, of course, on the increase. In order to provide for earlier and more widespread reproduction, it is desirable that the present game laws be amended so as to remove the protecton from the California gray squirrel, at least in the counties where there is coniferous timber.

SQUIRRELS AND SUGAR-PINE REPRODUCTION

BY E. V. JOTTER

Contributed

During the 1910 forest supervisors' meeting at San Francisco one of the resolutions passed concerned the damage done by squirrels to sugar pine during the seeding season. That such damage is being done is certain, and although the notes presented are insufficient evidence, they indicate that the scarcity of sugar-pine reproduction is due to the squirrel more than to any other agency.

The fact has been remarked in each seed year that long before the seed is ripe the cones are being cut off in such numbers by squirrels that there is often no ripe seed. Although it would seem that squirrels would instinctively know when to begin their work, cones are found beneath the tree from the time they are one to two inches long up to maturity. It would seem more natural if the cones were cut just before the seed ripens, since at that time it quickly leaves the cone. The following data illustrate a condition that is quite common:

Sugar-pine tree in deep woods, fifty inches at diameter breast high

August 20, 1911

Cones on ground:	
Size 1 by 2 inches	37
2 by 4 inches	28
4 by 6 inches	6
4 by 6 inches (eaten)	6
Cones on tree	None

The smaller cones are often not at first visible, but a little close inspection reveals many of these. Not only was the possible seed crop made worthless, but absolutely no benefit was derived by the squirrel.

Trees of all ages, all sizes and condition, and any site, seem to suffer equally in regions where squirrels are common. That near Weaverville a great many matured cones were seen on the trees may be attributed to the scarcity of squirrels because of the hunting done in that vicinity. The following examples are typical of areas where squirrels are found:

August 20, 1911

D. B. H.	Cones on ground.		Cones on tree.
Inches.	Eaten.	Uneaten.	
18	2	7	None
36	20	20	None
24	13	12	None
54	..	116	None
48	..	85	None
24	12	..	24
20	12	38	20
42	19	36	25
34	25	..	50
56	56	..	160

Naturally the later in the season that the observation was taken, or, owing to the location of the tree, the riper the seed, the greater the proportion of cut cones to those on the tree.

It would be entirely safe to estimate that 50 per cent of the sugar-pine trees had no seed at the time of maturity and that one-half the remaining trees had very little of the original crop.

Early in the summer Ranger Garrett attempted to protect a sugar-pine tree by tacking a band of tin 12 inches wide about the tree, 6 feet above the ground, making it impossible for the squirrel to climb the tree. This would have been effective had it not been for surrounding unprotected trees by means of which the rodents could jump into the sugar pine. These also were tinned, with the exception of one tree, which was, however, also used later by the squirrels. The figures therefore show no variation from the unprotected tree, although they do indicate the avidity and persistency of this little animal:

Cones on tree.	Cones on ground.	
175	8	July 1.
160	15	July 31.
11	164	August 24.

Ranger Gray has furnished this interesting information:

"The squirrel begins his work on the sugar-pine cones, cutting them from the trees when they are not more than 3 inches in length and continuing his work leisurely throughout the summer until all the cones have disappeared from the trees. Sometimes the seed has ripened before he has finished his work, though this, however, never happens unless it is an abundant seed year.

"During the month of August, before the seed were ripe, in passing an unusually large sugar-pine tree that was heavily seeded and which stood near my headquarters, I saw many freshly cut cones lying upon the ground. Thinking that it would be of some interest to know with what rapidity these little gray fellows carried on their work, I cleared all cones and pieces of cones from beneath the tree and spent some little time before I could ascertain the exact number of squirrels at work. I finally found that there were 7 working in this tree, and, returning to the place 24 hours later, I counted the same number of squirrels working as on the previous day. Lying scattered about the base of the tree were 36 cones that had been cut down during the past 24 hours, a few of these having been almost totally destroyed, others only partially, and a greater number not touched at all.

"A similar experiment on the day following showed 6 squirrels working and 33 cones scattered about the tree, as before described.

"While these figures in exactness are probably very incomplete, they show, rough as they are, very convincingly the damage that can be and is done by a single squirrel in one day. When this is multiplied by the days and months required to grow a seed crop, it is not at all amazing that the seed crop is often short at the time of ripening, although early in the season the prospect for a good crop appeared excellent."

Counts of the reproduction beneath and near sugar-pine trees were made frequently, and in the majority of instances no sugar-pine seedlings were found, although there may have been an excellent stand of Douglas fir or yellow pine. The forest descriptions of the reconnaissance field parties show that there is very little reproduction of the species under discussion.

During the past three years efforts at reforestation have been made by artificial means, and wherever the site was favorable sugar pine was sown. These efforts have been unsuccessful, and have value only in an experimental sense, so that little can be expected of them as a means of reforesting extensive areas of land adapted to timber. On such land, protected from fire, natural reproduction comes easily, and it would seem fully as important as any planting scheme to encourage the growth of such a valuable timber as sugar pine. Since the damage done by one squirrel cannot be replaced by many acres of planting, it would seem good forestry to permit the killing of squirrels at any time and in any number. The price paid for squirrel pelts, which is about 10 cents, would be sufficient inducement to remove this obstacle to forestry. Various ranchers state also that the tree squirrels are an increasing detriment to grains and fruits.

As a further indictment against the squirrel, there is the fire damage to large trees that results from the heaping of cones and scales about the base of the tree. Always mindful of danger, the squirrel selects his dining places at such points that afford a good lookout or a quick escape from possible foes. He tears apart the cones most frequently at the base of the parent tree or at similar trees near by, forming at each place an accumulated pile of litter, which, in burning, acts as kindling to the trunk of the large tree. Even a very light surface fire may do great damage to standing timber because of this inflammable rubbish.

I suggest, in view of all of this damage, that the Forest Service make a concerted effort toward remedying the present law in such a manner that squirrels may be killed at any time and in any number—that is, section 626*g* of the Fish and Game Laws, which reads as follows, should be repealed entirely, or exceptions of other counties in addition to Mendocino be made:

> "Every person who, between the first day of January and the first day of September of the same year, hunts, takes, kill or destroys, or has in his possession, any species of tree squirrel, or who at any time buys, sells, offers for sale, or has in his possession for sale, any tree squirrel, is guilty of a misdemeanor, and every person who takes, kills, or destroys, or has in his possession more than twelve tree squirrels during any one open season, is guilty of a misdemeanor; provided, that none of the provisions of this section shall in any manner apply to the county of Mendocino in said State."

Since the Federal Government, through the Forest Service, does not wish to be put on record as interfering officially with the State laws, I further suggest that supervisors interest forest officers and other citizens in this matter and that they be requested to sign petitions to their Congressman asking for the necessary change in legislation. Medocino County found little difficulty in changing this law, and it would seem that similar exceptions might be made elsewhere.

The district supervisors' meeting would furnish an opportunity for discussion of this matter and the formation of some plan of action.

RELATIVE ACCURACY OF CALIPERS AND STEEL TAPE

FORT VALLEY EXPERIMENT STATION

BY NORMAN W. SCHERER

Contributed

OBJECT

In measuring trees for permanent records, it is frequently necessary to obtain the diameter to the nearest one-tenth inch. If the position of the calipers varies ever so slightly in two successive measurements, especially on a rough bark, the error due to this factor might be several tenths of an inch. The use of a diameter tape, actually measuring the circumference, has been suggested as a more accurate method. The object of this experiment is to compare the accuracy of the caliper method with that of the tape method.

Location

North of the Fort Valley Experiment Station quarters, in a pure western yellow-pine forest.

Operations

One hundred trees 4 inches and over, d. b. h., were measured twice with a pair of calipers and twice with a steel tape.

Two caliper measurements at right angles were taken on each tree. The calipers were in good adjustment, and care was taken to hold them in a horizontal position. A nail was driven at breast height and the beam or arm rested on this in taking the measurement. The ring in the end of the tape was hooked on the nail, and the tape was passed around the tree as nearly as possible in a true horizontal line. Branches, swellings, and other abnormalities were avoided. In the tape, as in the caliper measurements, each man did the work without assistance from the other. Each tree was numbered with a tin tag at approximately 4½ feet from the ground.

The tabulated results of the different measurements by the two men, A and B, follow:

TABLE 1.—*Diameter measurements*

[All measurements in inches at breast height]

Tree No.	Calipers.				Tape.	
	Measured by A.		Measured by B.		Measured by—	
	East and West.	North and South.	East and West.	North and South.	A.	B.
601	21.6	21.8	21.7	21.7	22.0	21.9
602	21.0	22.0	20.9	21.9	21.5	21.55
603	18.1	18.5	18.0	18.2	18.4	18.5
604	23.0	22.8	22.9	22.5	23.2	23.2
605	20.2	19.8	20.3	19.9	20.4	20.4
606	22.1	23.2	21.9	23.2	22.9	22.8
607	18.8	20.4	18.8	20.2	19.7	19.5
608	22.5	22.5	22.5	22.6	23.6	23.55
609	20.5	21.6	20.8	21.3	21.5	21.5
610	23.7	23.2	23.6	23.2	24.0	23.95
611	31.0	30.7	30.8	30.0	31.1	31.1
612	15.6	15.4	15.4	15.3	15.5	15.5
613	9.6	9.5	9.6	9.5	9.9	9.9
614	8.3	8.1	8.2	8.2	8.4	8.4
[1] 615	8.2	8.4	8.1	8.3	8.4	8.4
616	16.2	16.7	16.5	17.1	17.1	17.1
617	15.6	14.9	15.5	15.1	15.7	15.8
618	15.3	14.3	15.2	14.2	15.2	15.2
619	13.9	14.3	14.0	14.1	14.4	14.4
620	15.7	15.4	16.4	15.2	16.3	16.4
621	12.9	12.7	12.9	12.4	12.9	12.9
622	18.9	18.5	18.3	18.7	18.6	18.6
623	30.5	29.4	30.3	29.4	30.6	30.6
624	23.6	17.2	23.5	17.5	21.6	21.6
625	31.5	33.1	31.2	32.1	32.9	32.85
626	20.1	19.2	20.2	19.0	20.2	20.25
627	22.0	23.6	22.3	23.5	23.3	23.1
628	21.5	22.9	22.2	22.5	22.6	22.6
629	31.1	30.6	31.0	30.4	31.4	31.45
630	19.6	19.9	19.7	19.7	20.3	20.3
631	31.7	32.1	31.3	31.7	32.0	32.0
632	20.8	21.3	20.9	21.2	21.5	21.5
633	31.1	32.7	31.3	32.5	32.7	32.7
634	32.8	31.0	32.5	31.0	32.4	32.5
635	26.4	26.5	26.1	26.4	26.5	26.6
636	24.6	24.5	24.5	24.1	25.0	24.9
637	23.2	25.8	23.2	26.0	25.0	24.9
638	22.7	22.7	22.6	22.4	23.2	23.1
639	27.5	26.1	26.9	26.0	26.8	26.8
640	24.4	25.8	24.2	25.2	25.2	25.3
641	22.6	22.0	22.0	22.1	22.6	22.6
642	14.1	13.6	13.6	13.6	14.1	14.1
643	23.9	24.6	23.5	24.5	24.9	24.9
644	22.7	23.6	22.5	23.4	23.9	23.8
645	12.6	11.5	12.4	11.4	12.2	12.2
646	10.7	10.8	10.8	10.8	11.0	10.9
647	10.6	10.8	10.5	10.8	11.2	11.2
648	16.8	17.0	17.1	17.2	17.4	17.4
649	7.8	7.5	7.6	7.2	7.7	7.7

[1] Measured at 4 feet.

Tree No.	Calipers.				Tape.	
	Measured by A.		Measured by B.		Measured by—	
	East and West.	North and South.	East and West.	North and South.	A.	B.
650	12.9	12.8	12.7	12.7	13.1	13.0
651	10.1	10.6	9.9	10.4	10.4	10.4
652	8.9	8.6	9.1	8.6	9.1	9.1
653	14.7	14.7	14.6	14.5	14.9	14.9
654	8.3	8.5	8.3	8.5	8.7	8.7
655	8.8	9.0	9.0	9.0	9.0	9.0
656	27.3	27.5	27.2	27.0	27.7	27.7
657	30.5	28.9	30.4	28.4	30.2	30.3
658	15.7	15.0	15.6	14.8	15.7	15.8
659	25.9	26.1	25.6	26.0	26.0	26.4
660	17.2	17.2	17.4	17.4	17.4	17.4
661	21.8	22.7	21.5	22.4	22.1	22.2
662	8.8	8.8	8.8	8.6	8.8	9.0
663	13.3	13.8	13.2	13.5	13.8	13.9
664	11.2	11.0	11.2	11.0	11.5	11.5
665	12.2	13.2	12.0	13.1	12.9	13.0
666	21.7	20.1	21.9	20.0	21.3	21.25
667	24.5	23.8	24.6	23.9	24.2	24.3
668	16.0	15.8	16.5	16.0	16.2	16.3
669	21.8	22.2	21.9	21.7	22.3	22.25
670	31.3	32.1	31.3	32.2	32.8	32.8
671	30.1	28.6	29.8	28.3	29.8	29.8
672	25.9	24.2	25.8	24.0	25.5	25.5
673	27.0	25.4	26.7	25.3	26.8	26.8
674	26.1	26.5	26.2	26.3	26.6	26.6
675	15.3	15.9	15.2	15.6	15.8	15.75
676	21.7	23.6	21.7	23.5	23.3	23.35
677	33.4	33.8	33.2	33.3	34.4	34.2
678	17.7	18.4	17.3	18.3	18.3	18.3
679	31.1	32.1	30.9	31.1	32.1	32.05
680	25.5	25.5	25.3	25.4	25.6	25.65
681	20.3	20.3	20.2	20.1	20.9	20.85
682	25.3	25.4	25.5	25.2	26.0	25.9
683	17.7	19.4	17.8	19.1	18.8	18.9
684	22.1	21.2	21.7	21.2	21.8	21.8
685	18.0	18.2	18.0	17.9	18.6	18.6
686	17.8	18.5	17.7	18.4	18.5	18.4
687	14.7	16.6	14.6	16.3	15.7	15.8
688	15.5	14.6	15.0	14.7	15.2	15.2
689	24.2	25.2	24.4	24.5	25.2	25.2
690	23.6	22.8	23.6	22.5	23.8	23.7
691	23.4	23.4	23.3	22.8	23.4	23.4
692	25.0	25.4	24.8	24.9	26.1	26.2
693	26.7	26.8	25.3	26.7	27.1	27.0
694	26.8	24.8	26.6	24.5	25.9	26.0
695	27.4	28.7	27.1	28.6	27.6	27.7
696	20.6	20.2	20.6	20.1	20.3	20.3
697	18.1	18.1	18.1	17.9	18.5	18.4
698	15.7	15.8	15.5	15.5	15.9	15.9
699	12.2	12.7	12.2	12.4	12.8	12.8
700	18.9	19.8	18.8	19.5	19.8	19.7
Total (100).	2,030.3	2,033.8	2,020.8	2,018.0	2,067.0	2,067.6

Comparisons

1. Between caliper and tape measurements of the same man:

	A	B
Tape, total inches, 100 trees	2,067.0	2,067.6
Caliper, total inches, 100 trees	2,032.05	2,019.4
Difference for 100 trees	34.95	48.2
Difference for 1 tree	.349	.48

2. Between caliper measurements (mean of two at right angles) of the two men:

A, total inches, 100 trees	2,032.05
B, total inches, 100 trees	2,019.4
Difference for 100 trees	12.65
Difference for 1 tree	.126

3. Between tape measurements of the two men:

A, total inches, 100 trees	2,067.0
B, total inches, 100 trees	2,067.6
Difference for 100 trees	.6
Difference for 1 tree	.006

4. Trees in two diameter classes, showing the number in each class which have differences of 0.0, 0.1, 0.2 inches, etc., between the average caliper measurements of the two men, and between the tape measurements of the two men:

TABLE 2.—*Comparison of caliper and tape measurements.*

	Calipers.			Tape.		
Differences.	18 inches and above.	Below 18 inches.	Totals.	18 inches and above.	Below 18 inches.	Totals.
0.0	14	8	22	39	24	63
.1	20	15	35	23	9	32
.2	15	10	25	3	1	4
.3	12	1	13	......	......	......
.4	2	......	2	1	......	1
.5	......	......	......	......	......	......
.6	1	......	1	......	......	......
.7	2	......	2	......	......	......
Total...	66	34	100	66	34	100
		66			66	
		100			100	

Conclusions

From a comparison of the figures, it is evident that for studies involving any accurate comparison of diameters measured at different times and by different persons, the diameter tape is far more reliable than the calipers. One source of error in the calipers is that two persons will not place them in exactly the same position, nor will they exert the same pressure upon the arms. Even if the personal equation were eliminated, if measurements are made at intervals of five or more years it is evident that on account of the irregular plating of the bark the results will not represent the true growth in diameter. With the tape all the irregularities of the tree are taken into account, thus affording a better opportunity for compensating errors, and giving a truer measure of the real diameter of the tree.

It was the opinion of the caliper men that, after the nails were driven, one measurement with the tape could be made in less time than two measurements at right angles with the calipers, but since no records were kept of the time of each operation this comparison should not be accepted as conclusive.

Recommendations

There is no doubt as to the conclusiveness of the experiment with respect to the relative accuracy of the two methods. In order to compare them wiith respect to time required, at least 200 trees should be measured by one man by each method, keeping an accurate record of the time after the nails have been driven. While the tape method requires that a nail be driven into the tree or that the end of the tape be fastened by some other means, this is not to be regarded as an extra operation chargeable against the method, because even when calipers are used for work of this nature the point of measurement must be marked.

It is recommended that the diameter tape be substituted for the calipers in all permanent sample-plot work, involving periodic measurement of trees.

REVIEWS

INFLUENCE OF THE SOURCE OF SEED UPON THE CHARACTER OF FOREST GROWTH[1]

For many years there has been a diversity of opinion among foresters regarding the influence of the locality from which forest-tree seeds are collected and the characteristics of the mother tree upon the resulting crop. One group of foresters, led by Mayr, have advocated the general principle: "Variations in the characteristics of a given species, such as rapidity of growth, bole and crown form, frost hardiness, storm resistance, etc., resulting from soil and climatic conditions under which the mother tree develops, are not transmitted through the seed." Another group of foresters, led by Cieslar, Engler, Huffel, Zedebauer, and Kienitz, adhere to the general principle: "Variations in the characteristics of the mother tree due to soil and climate may be transmitted through the seed." To what extent the origin of the seed influences the growth, resistance, and form of forest crops is of vast importance in forest culture. In order to secure more precise information on this subject, many of the forest experiment stations of Europe have given special attention to it during the past two decades. Seeds of Scotch pine, Norway spruce, and other species have been secured from mother trees growing under a wide variation of soil and climatic conditions. The characteristics of the mother trees were carefully noted and the seeds were sown under uniform conditions that variations in the resulting trees due to the origin of the seed might be accurately compared. The resulting plantations in Germany, Austria, France, and Switzerland are now sufficiently advanced to permit of definite conclusions on many of the points involved.

From experiments conducted at Mariabrunn, Austria, Cieslar has shown the importance of climatic varieties of forest trees in the practice of silviculture. The later experiments of Zederbauer at the same place not only indicate that seed collected from suppressed or subdominant trees produce plants less resistant to disease than plants grown from seed collected from dominant trees, but also that the individual characteristics of the mother tree, such as unusual divergence from the typical form of the species, may be transmitted through the seed.

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[1] Engler, Arnold: Einfluss der Provenienz des Samens auf die Eigenschaften der forstlichen Holzgewächse. (In Mitteilungen der Schweizerischen Centralanstalt für das forstliche Versuchswesen, Zürich, 1905, Vol. 8: 81-236; 1913, Vol. 10, No. 3:1-386.)

A. Cieslar, Prof. Dr.: Centralblatt für das gesamte Forstwesen, 1907, s. 1.

E. Zederbauer, Prof. Dr.: Centralblatt für das gesamte Forstwesen, 1912, s. 201.

Dengler, Dr.: Zeitschr. f. Forst- und Jagdwesen, 1908, s. 137.

M. Kienitz, Dr.: Zeitschr. f. Forst- und Jagdwesen, 1911, s. 4.

G. Huffel, Prof.: Revue des Eaux et Forêts. 1912.

From experiments conducted at Eberswalde, Prussia, Dengler has recorded marked variations in the rate of growth in Scotch pine grown from seed collected near Ebarswalde as compared with seed from more northern localities. Kienitz in experiments at Chorin, near the same place, records wide variation in the form of the bole and crown of Scotch pine, as well as variation in root and shoot growth, depending upon the soil and climatic conditions under which the mother trees developed.

Huffel from observations and investigations at Nancy, France, records the effect of the locality from which the seeds of Scotch pine are derived upon the quality of the plants grown from them.

In 1905 Prof. Arnold Engler published the first part of his monograph on "The influence of the place of origin of the seed upon the character of forest growth." The second part of this monograph is only recently from the press. Because of its comprehensive character and evidently careful manner in which the experimental plantations were made, it merits the following rather comprehensive review. This part is confined almost entirely to investigations on the influence of the origin of Scotch pine seed upon the character of the resulting stand during its juvenile growth. One hundred and seventy-five pages are given to this study, accompanied with tables and illustrations. The study is introduced by a short review of the newest literature on one or more phases of the same general subject. The importance of the subject and its present interest to foresters is shown in the abundant recent literature. Twenty-seven references, many of comprehensive character, are quoted as appearing since 1905.

The investigation is presented under the following three general headings:

1. The general distribution and growth forms of the Scotch pine and its importance in Swiss forestry.
2. The research material and the method of investigation.
3. The results of the investigation.

Fifty-nine separate lots of Scotch pine seed comprised the research material. Special attention was given to the descent and source of the seed. A comprehensive table shows at a glance the important characteristics of the mother trees and the habitat conditions under which they grew. The seeds were obtained from various localities in Switzerland, Germany, Austria, Belgium, Russia, Norway, Sweden, and Scotland. Forty-four samples were collected from normal trees and fifteen from trees more or less diverging from the normal in growth-form. As each sample was collected a detailed record was made of the latitude, longitude, altitude, aspect, geological formation, and other characteristics of the site where the mother tree grew, and the height, diameter, age, growth-form, other species in the stand, time of seed collection, and by whom the cones were collected.

In all, nine series of investigations were undertaken. Fifty-five lots of the seed from as many different localities were sown in four nurseries in Switzerland, located at various altitudes and under various soil conditions—viz, at Adlisberg, Lütisbuch, Knirl, and Blumatt—from which a total of 175,000 two-year seedlings were obtained. In each nursery the method of culture was the same.

Plants obtained from each lot of seed, usually when two years of age, were transplanted from the nurseries to permanent plantations. These plantations were made in eleven localities in Switzerland and varied in altitude from 370 meters to 1,980 meters. A detailed account is given of the soil and climatic conditions of each planting site, the age of the stock when planted, and the age to the end of the year 1912; also the area, total number of plants set on each site, their origin, spacing, etc.

The results of the investigation are presented under the following headings:

1. The character of the cones.
2. The character of the seeds.
3. Growth and growth-form of 1 to 7 year old Scotch pine from the different localities.
4. The resistance of Scotch pine of different origin against the fungus, *Lophodermium pinastri*.
5. The variation in winter color of the Scotch pine.
6. Summary of results and conclusions.

The investigation of the cones in large numbers from localities having widely different climatic and soil conditions shows marked differences in size, color, form, and the thickness and form of the scales. Moreover, these differences appear to be correlated to a certain extent with differences in the soil and climatic conditions under which the mother trees developed. A table shows for each lot of cones the place of collection, the year of collecting, the weight of seed per given weight of cones, and their average size, weight, volume, and specific gravity. It also shows the average weight per thousand seeds and the germination per cent of the fresh seeds.

Experiments were conducted during the years 1906 to 1912 with the same lots of seed to determine the decrease in germination with the age of the seed. Experiments were also made to determine the germination energy as well as the germination per cent. The results obtained from the examination of the various lots of seed are as follows:

1. In high situations in the Alps and on high plateaus the kernel and wing of the Scotch pine seed as a rule is brighter colored than in low-lying and more southern regions. Color, however, is not a certain character for determining the locality from which the seeds are derived.
2. Scotch pine seed from high situations in the Alps and from Norway and Sweden is lighter than from the table-lands of middle Europe and southern France.
3. The fresh seed had a considerably higher germination per cent than the ordinary commercial seed. In high situations in the Alps and in northern Sweden, Scotch pine seed possess a considerably lower germination per cent than in localities with milder climate.
4. During the first two years from the collection of the cones the seeds maintained their germination per cent when well stored, with only slight reduction.
5. The investigations bring to light no infallible characteristic by which the certain determination of seed habitat can be known from the appearance of the seed.

Special attention is given to the growth and growth-form of the seedlings from the various localities for a period of one to seven years following germination. A comprehensive table records the green weight per hundred plants grown from the various lots of seed at the different nurseries, and the maximum, minimum, and average height growth of one and two-year-old seedlings. Another table records the average length of the rot, hypocatyl and epicotyl, of the one-year-old seedlings, the number of leaves and their length, size and color of the buds, and the color of the foliage. A final series of tables record the growth and growth-form of five and seven-year-old plants grown from the various lots of seed in nurseries and set in the various plantations already noted. This table records the original number set out, the loss per cent from each lot of seedlings, the maximum, minimum, and average vertical height growth for the year, the number of trees in each of four growth classes, and the percentage of the total number in each class. Accompanying the tables is a full discussion of the data and illustrations showing Scotch pine grown from seed from different localities, in which the trees exhibit marked differences in growth, form, resistance, color of foliage, etc., when planted and grown under approximately uniform conditions.

The following are among the more important conclusions from the study of the seedlings in the various nurseries and plantations. One and two-year Scotch pine seedlings decrease in height growth with the increase in the altitude of the site from which the seeds are obtained; in Scandinavian seed, with the increase in the latitudinal range of the situation. The largest seedlings were raised from seeds from Alsace-Lorraine, and the smallest from seeds from middle and northern Sweden. In the first year Scotch pine grown from seed from each of the localities closed its height growth very late—that is, in late summer or autumn. In all instances, however, the seedlings from Scandinavian and east Russian seed completed their height growth one or two months earlier than those from Swiss and German seed from low elevations. The two-year-old plants all completed their height growth at the same time, from the end of May to the beginning of June. There appears to be justification for the segregation of new forms or varieties from the species *Pinus silvestris* L. The six to seven year old plants took their growth characteristics with one exceptional case from the altitude and latitude of the locality from which the seeds were obtained. The exception appeared in the descendants of the Ungedine pine. The greatest height growth in six to seven year old plants was in those grown from seed from low situations in Switzerland (Eglisau, Adelsberg), districts of southwest Germany, northern Switzerland, east Prussia, and Belgium; the finest growth-form was in plants grown from seed from east Prussian and Belgium. Seed from east Prussia, northern Switzerland, Scotland and east Russia produced the finest and largest plants when grown in the low-lying Swiss mountains (Kümberg, Magglingen). The plants grown from the French seeds appeared to be well adapted to the dry highlands of the Jura. Southwest German pine is very fast growing but suffers very badly from snow break.

On the high Alpine sites (Samaden, Celerina, Scamfs, Davas) plants grown from the seeds of the Ungedine pine surpassed all others in healthfulness and general excellence. They compared well in height growth with the rapidly growing pine from southwest Germany and northern Switzerland. Plants grown from seed collected at other high elevations in Switzerland also grew well on the above sites. The plants grown on these sites from seed collected in east Russia and middle Scandinavia have also done well up to the present time. Plants grown from French, southwest German, and north Switzerland seed on these high sites have poor growth-form and the last two sorts suffer from top drying.

On low sites with mild climate the height growth of the plants from each lot of seeds begins at approximately the same time. On high sites, however, the plants from seed collected on high mountains and in Scandinavia begin their height growth earlier than is the case with plants from seeds from middle European lowlands.

The terminal growth of plants from northern Switzerland and German seed increases with increased temperature considerably more than is the case with plants from northern and Alpine seed. The rapid terminal growth stops earlier, however, than is the case with the latter. The growth of the northern and Alpine pine is accompanied by proportionately lower temperature and a shorter vegetation period. The Ungedine pine accommodates its growth to a milder climate than is the case with Alpine and Scandinavian pine. Whereas in two-year-old pine the height growth closes approximately at the same time, in five-year-old pine the northern and Alpine form closes at one time and the middle European form at another. At Adlisberg the height growth of five-year-old pine from northern and Alpine seed closed fourteen days earlier, and six to seven-year-old pine twenty-one days earlier than those from middle European seed. The height growth of the plants closed earlier the higher or more northern the region of the seed. The frequent appearance of top drying on pine in high situations grown from lowland seed is due to the late closing of growth.

The seedlings grown from seed from crooked-stemmed, spreading, crippled mother trees are for the most part of very poor form. In all of these cases the mother trees developed on poor, lean soil. Where the poor form of the mother tree is due to weather effect or damage by man or beast, the poor form is not carried over into the next generation through the seed. Poor growth-form, however, due to poor soil and climate, can be transmitted through the seed.

The Scandinavian and east Russian pine appear to be the least resistant to the fungus, *Lophodermium pinastri;* the French and east Prussian appear to be more resistant, but not entirely so. The needles of the young pine take on for the most part a yellowish or brownish color in autumn or winter. The plants from east Russian and Scandinavian seed take on this color earlier and the color is deeper. The least amount of color appears in the French and Belgium or Scotch pine. The winter color of the Scandinavian pine increases in intensity with the latitudinal range; of the Alpine, with increase in altitude of the site from which the seeds are obtained. The yellow and brown winter color is an accommodation adjustment to weather conditions. It is characteristic of regions having a cold, dry winter, the color being induced through the falling of water absorption, by the relatively high evaporation, and through the diminished water supply of the plant. When one brings plants into the greenhouses in mid-winter it seldom takes the deepest-colored east Russian and northern Sweden plants but ten to fourteen days to assume their full summer green color.

The author concludes from this comprehensive study of the Scotch pine and from previous investigations that stands having poor growth-form are not suitable to collect seeds from for use in forest practice. Poor growth-form comes from adverse soil conditions and from the use of seed from the wrong locality. In both cases the research shows it can be transmitted through the seed. For each locality the indigenous spontaneous pine is the best to collect seed from for use in that locality. Exotic seed, however, may be used when its origin is known. Thus seed from east and west Prussia is acceptable for use on low elevations in Switzerland, not to exceed 1,000 to 1,200 meters above sea-level. South German seed may be used on the lowlands of North Switzerland. The Auvergne pine may be expected to thrive on the dry soils of the Juras.

When exotic seed is used it should be with full knowledge of its descent and of the locality where collected. This knowledge, however, can only be attained through government supervision. We now know that the failures in the cultivation of pine in the Swiss mountains in recent years have been due to the use of seed from the wrong localities.

It appears to the reviewer that the results of Professor Engler's researches on Scotch pine and Norway spruce, and similar investigations in recent years by other investigators, clearly show the necessity of giving more attention in this country to the descent of the seed that we use in forest practice.

With the use of such widely distributed species as western yellow pine, Douglas fir, and even white pine, the success attending their culture in any particular locality may be largely determined by the descent of the seed.

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INFLUENCE OF THE ORIGIN OF SEED[1]

The influence of the origin of pine (*Pinus silvestris*) and spruce (*Picea abies*) seed for artificial forestation has been investigated by Edvard Wibeck of the Swedish Experiment Station. For many decades it has been observed by Swedish foresters and owners of woodlands that foreign, particularly German, pine seed produces plantations markedly inferior to those from domestic seed. As early as 1882 the Swedish

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[1] "Tall Och Gran Af Sydlig Härkomst i Sverige." By Edvard Wibeck. Meddelanden fron Statens Skogsförsöksanstalt, Stockholm, Häftet 9, 1912, pp. 75-134.

Forest Service issued a warning against the use of foreign pine and spruce seed, and, in order to check importation, imposed a duty which in 1888 and 1911 was increased for pine to such a figure that it practically resulted in exclusion.

Notwithstanding the almost universal recognition of the undesirability of foreign pine seed, a number of important questions remained unanswered. Foremost among these was whether all foreign seed was equally undesirable. There were good reasons for questioning the advisability of excluding seed from northern regions—for instance, northeastern Germany, Finland, Norway, and certain provinces of Russia.

The study occupied two years, 1909 and 1910, during which Mr. Wibeck examined a great number of plantations in almost every province of Sweden, and also visited representative pine regions in northern and western Germany.

Some of the difficulties attending the investigation were the lack of definite boundaries between plantations of different years, complications due to replanting, the mixing of planted trees with natural reproduction, and the fact that in many instances the seed had been of mixed origin. In many cases it was impossible to trace the origin beyond the seed dealer, and consequently little reliable information was gained.

The article contains a very complete list of literature on the subject and cites the results of investigations and observations in other countries.

In Norrland, one of the extreme northern provinces of Sweden, it is maintained that, for the pine, not only German seed, but also that from southern Sweden, produces trees inferior to those grown from local seed.

In Norway the experience with German pine seed has been similar to that in Sweden, with the result that in 1880 there was a strong movement toward domestic seed collection. As in Norrland, pine seed from southern Sweden proved inferior to that of local origin, although the difference was not so great as between Norwegian and German seed.

Since native pine does not occur in Denmark, no direct comparison could be made between native and German seed; but it was pointed out by Rostrup in 1882 that pine seedlings grown from Swedish seed were practically free from the attack of the fungus *Lophodermium pinastri,* while those grown from German seed were destroyed.

In Livland and other provinces of Russia the use of west-German (Darmstadter) pine seed, according to Von Sivers and Turski, has resulted in experiences precisely similar to those in Sweden.

In Germany recent experiences have shown that French pine seed is inferior to the domestic product and that there is also a difference between seed from different German provinces. Great quantities of French pine seed have been imported by Germany, 55,000 k. g. having been brought in by one firm alone during the winter of 1908-1909. The author states that what German seed has been to Sweden, French seed has been to Germany, and expresses his astonishment at the slowness of the Germans in recognizing this condition. In March, 1910, however, an official warning against the use of foreign pine seed was issued, and recently an association has been formed by a number of seed and tree firms which guarantee to furnish true statements in regard to the origin of their seeds.

There are quite noticeable differences in the form and general habit of Scotch pine in different parts of Europe, although these differences do not hold for every individual in the stands. The native pine of Sweden and other northern countries, notably Norway and northern Russia, is characterized by narrow, pointed crowns, short branches, light, thin, close-scaled bark, persistent cones, and small seed. The pine of France and southern Germany is characterized by broader crowns, longer branches, dark grayish and coarsely furrowed bark, less persistent cones, and larger seeds. The northern form is not limited to northern latitudes, however, since it occurs also at high altitudes even in southern France and in the Balkans.

Two theories have been advanced in explanation of the origin of the local forms of pine. One is that through the process of natural selection those individuals which were least adapted to the habitat were eliminated. Thus one form has come to predominate in one region and another in another region. Kienitz sees in the snow pressure an important factor in determining the crown form; thus in regions of heavy snow damage the broad-crowned individuals would suffer most, while in regions where there is less danger from snow the broad crowns would be of advantage in the struggle for light. Metzger points out that the northern pines' long, narrow crown is especially adapted to the long periods of side light which prevail in the northern latitudes. The vegetative period is also an important factor, since this varies from three to eight months in different parts of the tree's range. The other theory is that the pine possesses an innate power of adaptation, which enables it to develop the form best adapted to the conditions of the region in which it occurs (Neo-Lamarkism).

Whatever may be their origin, the fact remains that local forms do exist which justify the name "climate race," inasmuch as they harmonize with the physical factors of their habitat. Since the pine, when it is transplanted to a new region, cannot, at least during the first generation, materially modify its hereditary characters, it falls into more or less disharmony with its environment. These are the conditions at the bottom of the so-called "German pine disease" in Sweden.

The local forms of spruce have been much less studied than those of the pine, evidently because the spruce, through its behavior on being transplanted from one region to another, has given less occasion for such study. There are, however, differences due to the origin of the seed, although less marked than in the pine. The spruce of the far north is characterized by a very narrow, almost cylindrical crown and rather scanty branches. The cone is relatively short, and the upper half of the cone shales is semicircular. The tree is adapted to a short growing season and the growth is exceedingly slow (Fennica type). Farther south the crown becomes more conical, with longer and more uniformly divided branches. The cones are larger and the cone scales wholly or preponderatingly of rhomboid form (*europæa*). The vegetative period is longer and the growth more rapid than in the case of the northern form.

The experience with German pine seed in Sweden has given rise to the popular term "German pine," which is applied to all more or less crooked-stemmed, long-limbed, short-lived pine stands whose inferior qualities cannot be ascribed to the quality of the site. The term "German pine" is used regardless of the true origin of the seed. While the bulk of the seed undoubtedly came from Germany, it is probable that considerable quantities also came from France and Belgium. It is pointed out by the author that not all German pine seed sown in Sweden has produced inferior stands, and that not all inferior stands are from German seed.

It is the author's opinion that the importation of foreign seed does not date back much beyond 1840. At least 20,000 k. g. of pine are known to have been imported from 1888 to 1909, and it is estimated that at least three times that quantity came in before 1888, thus bringing the total to from 60,000 to 80,000 k. g.

About 17,000 hectares have been planted or sown in Sweden with imported pine seed. Of this, some 5,000 to 6,000 hectares have within recent years been cut down or died out naturally. Few plantations of "German pine" now exist which are over 40 years of age, while many died during the first few years.

The specific characteristics of "German pine" are of two kinds: partly hereditary race peculiarities acquired in the original habitat and partly abnormal form developments arising from its inability to adapt itself to new conditions. While it is impossible to make a close distinction between these two classes of characteristics, it may be said that in general the former class is more in evidence during the first few years of the tree's life, while the latter class appears later, growing more and more prominent from year to year, and partly obscuring the former. Obviously the characters vary with the origin of the seed, and the abnormalities are greater the greater the difference between the present and the original habitat. Since the "German pine" stands originate in widely different localities, there is a wide variation in their characteristics, and there are all gradations between those which can scarcely be distinguished from native Swedish stands and those which begin to pine away during the first few years and die at from 10 to 15 years of age.

As the German seed is larger than the Swedish, so also are the seedlings from the former larger, and unless they are injured by frost or disease, to which they are more susceptible than the native Swedish plants, they grow to a larger size in a given period of years. Experimental areas sown in 1904 and 1905 with seed from Eberswalde, Germany, southern France, and various parts of Sweden show, after five to seven years, a greater height for the foreign plants. Excepting on two areas, where the plants from French seed were by far the largest, those from Eberswalde seed showed the greatest length. On all but the above two areas the French seedlings suffered from frost, which accounts for their relatively small size. One plot of French pine seedlings was entirely killed by frost in the spring of 1911, while adjoining plots from Swedish and German seed were practically uninjured.

Although the pine in most of the regions whence the imported seed came has a strong tendency toward forming crooked stems and coarse branches, these characteristics are still more emphasized when the tree is transplanted to a more northerly climate. The characteristic pyramidal form of the young Swedish pine even in open stands is much less developed in "German pine" plantations in Sweden, and the stands lack the characteristic parallel formation which generally meets the eye on gazing into a dense coniferous forest. In extreme cases, particularly in higher altitudes, the stems of the "German pine" become S-formed or trailing, as in the mountain pine. The stems often show large swellings at the whorls, and the bark ruptures and scales off in an abnormal manner. The branches are long, and rise at a sharp angle so that the upper ones are almost even with the leader. The crooked form and other abnormalities, which usually appear in the second or third decade or sooner, overshadow the rapid early development, and gradually the tree begins to die.

One explanation of this condition lies in the short growing season. The "German pine" begins growth earlier and ceases later than the native tree, a fact which renders the former more sensitive to frost. The first heavy snows find the year's shoots of the "German pine" still soft, with the result that there is much bending and breaking. Frost and snow pressure are probably responsible for the majority of the minor mechanical injuries and cracks in the bark, which afford points of attack for various fungous diseases, particularly the pine cancer (*Dasycypha calyciformis*), which does much damage to the "German pine," but rarely injures the native pine. Since "German pine" generally dies out, or is in a dying condition before the age of cone-production, there is little danger of degenerating the forest through its reproduction.

Left to themselves, the dying pine stands are rapidly transformed into other, stronger plant associations. Generally this takes place through invasion by birch and spruce, and occasionally by the beech. Under less favorable conditions the ground becomes covered by heather, with practically no tree reproduction. In such cases underplanting with spruce is sometimes advisable, but the pine must later be cut out. All attempts to establish a mixed stand under such circumstances have failed.

The better survivors of the "German pine" stands, despite their bad form, even at an age of thirty years often show a greater height and volume growth than native pine of the same age; but the material is always of low value. No real work-wood can be counted on, only firewood, charcoal, paper pulp, and similar material, which often does not pay the expense of cutting and marketing. Only in the most southern provinces are there occasional instances on record where a "German pine" plantation has yielded a net return.

The loss from the use of imported seed is not limited to the direct loss of the plantations; there are additional indirect losses resulting from the development of erroneous ideas in regard to forestry. Among the latter are mentioned the discouragement of public interest in artificial forestation, and the development of the opinion that artificially established forests are inferior to those of natural origin. The failure of so many plantations has also contributed to the popular notion that certain localities have become degeneration zones for pine. Mr. Wibeck's theory of the evolution of the so-called degeneration zones is as follows: The best trees, being most in demand for construction, were the first to be cut; and because of certain peculiarities, which he does not specify, they were less able to compete with certain other trees, notably the beech. The remaining stands were therefore the result of a process of selection which removed the best mother trees and left the inferior ones. Adding to this the fact that many of the best stands were, after cutting, replaced by plantations of "German pine," and that the remaining native stands were usually on inferior sites, it is easy to understand how the standard of the forest in certain localities has been materially lowered. The fact is that even within the so-called degeneration zones occur stands of the very finest development, which is considered ample proof that there have been no material climatic changes detrimental to the growth of pine.

With respect to spruce, the investigations are less conclusive than in the case of pine. While the importation of spruce seed has been even greater than of pine seed, the author states that it is very difficult to secure any reliable information on spruce stands from foreign seed. This fact in itself seems to indicate that spruce from foreign seed does not present any striking abnormalities. Usually the German spruce plantations show very rapid growth. Two fifty-nine-year-old plantations known to be from German seed have 2,068 and 1,904 trees per hectare, with a corresponding volume of 652 and 686 cubic meters. It is the general opinion among Swedish foresters that German spruce is well adapted to Swedish conditions, excepting perhaps in the extreme north and in high altitudes. Opposite opinions, the author thinks, are based mainly upon theory, transferring the common experience with pine to the spruce. In Finland spruce from German seed has been found to be susceptible to frost injury up to the age of twenty years or more. The Experiment Station contemplates further investigation of the spruce by establishing comparable plantations from Swedish and German seed.

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UEBER WALDTYPEN (FOREST TYPES) [1]

The work is the result of an investigation on herbaceous and forest associations carried on in Finland, as well as in Germany, Austria-Hungary, Switzerland, northern Russia, and the Siberian virgin coniferous belt. The purpose of this investigation was to determine the extent to which the study of plant associations, which until recently had only a scientific botanical and geographical interest, is of practical importance in forestry. The author states that in the last few decades an attempt has been made in Sweden to study forest associations or so-called "forest types" (Waldtypen, Skogstypes). In some private timber lands forest types are laid at the foundation of forest mapping, forest organization, and forest management in general.

The book consists of four chapters. In chapter I the author discusses plant associations in general.

The character of vegetation is determined by several factors, such as climate, soil, animals, parasitic plants, and others. The main factors, however, are climate and soil. As these two factors change only gradually and imperceptibly, the transition from one plant association to another would be also very gradual if there did not exist another factor, namely, the struggle for existence among plants. Because of this struggle the individual plant associations separate more clearly one from another. It leads to the formation of more or less pure associations, pure stands, and the longer the struggle has continued without interruption the more uniform is the vegetation. Of two species which originally may form a stand the site ultimately will retain only one species; as an example, he cites the Siberian virgin coniferous forest, which consists for the most part of pure stands. This rule, however, is not without exceptions. Thus, in the north there are often found on fertile soils very stable mixed stands. This is also true in western Europe and in tropical regions. The more favorable the conditions of growth the more complex is the composition of the stand.

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[1] By Prof. A. K. Cajander, Helsingfors, 1909, Fennia 28, No. 2, 175 pp.

Chapter II discusses the forest types of Germany. Professor Cajander accepted the living ground cover as a basis and with its aid attempted to distinguish forest types which should be taken into consideration in forestry practice. In a forest which has not been touched by man the composition of the forest itself is the best criterion of the physical conditions of growth as well as the living ground cover. In forests, however, which are under the influence of man only the living ground cover may serve as a criterion and indicator of the physical conditions of site. In his travel through Germany, Professor Cajander visited many forests. These were composed largely of spruce, fir, beech, and oak. He classified these forests into three types, as follows:

1. Forests with living ground cover of *Oxalis acetosella* (oxalis or sorrel type).
2. Forests with living ground cover of *Myrtillus nigra* (Myrtillus huckleberry type).
3. Forests with living ground cover of *Calluna vulgaris* (Calluna heath type).

Each of these types is characterized by the typical plant forms composing the ground cover in the three stages of the life of the stand, the seedling stage, sapling stage, and at maturity. The first or Oxalis type includes stands of the best growth, chiefly on deep fertile clay, sandy or limestone soils with porous sweet humus. The tree species composing this type embrace almost all of the trees that grow in Germany. The Oxalis type is further subdivided by the author in four subtypes, again on the basis of the living ground cover, as follows:

1. Stands with ground cover of *Impatiens* (touch-me-not) and *Asperula* (sweet woodruff).

2. Stands with *Asperula odorata.*
3. Stands with *Oxalis acetosella.*
4. Stands with Oxalis and *Myrtillus nigra.*

He describes at length the living ground cover of each of these subtypes. The growth of the stands is characterized by the cross-section area of the trees at stump and by their height. They are further described with regard to the different methods of regeneration practiced in them.

The second, or Myrtillus type, is found also on a variety of soils, but as a rule on less fertile soils than stands of the first type. On the basis of the living ground cover this type is subdivided again into four subtypes:

1. Stands with a living ground cover of *Rubus idæus* (raspberry).
2. Stands with a living ground cover of *Aræ flexuosa* (wavy aira).
3. Stands with a living ground cover of *Myrtillus nigra* (huckleberry).
4. Stands with a living ground cover of *Calamagrostis* (reed grass) (Halleriana). The forest itself is composed of a number of different species.

The third, or Calluna type, is confined to the poor, dry, sandy soils. The humus is only from 1 to 1½ centimeters thick and is of an acid reaction. The dominant species in the stand is pine; sometimes it is mixed with spruce of poor development.

As is readily seen, the composition of the forest cover itself does not play any part in defining the type, but only the living ground cover. As a result of his investigations the author comes to the conclusion that the different forest stands which he examined in Germany are readily grouped on the basis of the living ground cover into a comparatively small number of types, and that these are determined not by the soil alone, or exposure, or the chemical constituents of the soil, but by the aggregate effect of all the factors of site.

In chapter III he dwells especially in full on the crown forest Evo, in central Finland. After a brief description of the geology and the soil of the forest, he describes two main forest types:

1. With a living ground cover of Calluna (Calluna type), and 2, with a living ground cover of *Myrtillus nigra* (Myrtillus type). The first type is confined to sandy soils. The stand is composed almost exclusively of pine, with occasional admixture of spruce. He subdivides this type into three subtypes also on the basis of the living ground cover. One is characterized by a ground cover of lichens and heath; the second subtype by heath, and the third by a large admixture of mosses and berry bushes. In the first subtype only one single scrubby spruce was found, while in the third the admixture of spruce was greater, but it was always from five to twenty years younger than the pine stand.

Closely connected with the second type (Myrtillus type) are two other types, one with a ground cover of Vaccinium (Vaccinium type), and another with a ground cover of Majanthemum and Oxalis (Majanthemum and Oxalis type). The first of the last two types is found chiefly on fresh sandy soils with some spruce in mixture as an understory, the second on most fertile soils. From the long historical review of forest management in the crown forest Evo, from the beginning of the last century up to the present date, it appears that in stands with a ground cover of *Calluna vulgaris* selection cuttings proved unsatisfactory, but that natural regeneration as well as direct seeding of local seed gave equally good results. The facts established on the crown forest of Evo clearly indicate again that forest types are dependent not exclusively on the geological origin of the soil, but are brought about by several factors, among which, however, the soil is the most important. Professor Cajander strongly believes that the great variety of forest stands may be reduced to a small number of types on the basis of the living ground cover; that the same living ground cover can appear only when the physical conditions of growth are absolutely the same; that within the same type the increment in the stands does not vary considerably, and that the application of the same silvicultural measure for securing regeneration will yield on the whole similar results.

In the fourth and last chapter, Professor Cajander discusses the importance of forest types for forest management. He points out that no yield tables can be accurate in their application unless they are confined to forest types. The actual practice of forestry in his opinion must wholly rest on the study of forest types. Stands in river bottoms, swamps, dunes, etc., are different biological units, and for this reason require different silvicultural measures. There should be as many different silvicultural methods of forestry as there are forest types. It is not enough to speak of "pine" or "spruce" stands, as pine in one situation is not the same as pine in another situation. Quality class is very indefinite in character; it is an artificial conception, as a pine stand of a given quality class may be found on dry sands as well as in swampy situations. In forest management forest types must be accepted as the managerial silvicultural units, which should be taken into account in the preparation of plans of management in determining upon a given rotation, etc.

Finally, the author shows that foresters in Finland have for a long time recognized, although in a very primitive way, physical conditions of growth and forest types. As no forester is in a position to determine accurately the boundary between a dry and fresh soil, the difference in forest types must always be based upon the character of the living ground cover as the clearest indicator of the site.

Such in brief are the contents of this interesting work. We believe with the author that the main factors which determine the character of plant associations are climate and soil. In the further development of his ideas, however, he seemingly recedes from this principle of classification of forest associations on the basis of soil, preferring apparently to group them into types on the basis of the living ground cover. It is true that his description of types is always preceded by a brief characteristic of the soil, yet he repeatedly emphasizes that the division, for instance, into subtypes is made entirely on the basis of the living ground cover. In this we can hardly agree with him. The living ground cover as a rule can not serve as a reliable indicator of the chemical and physical properties of the soil as it is very changeable and sensitive to many other influences. A slight change in the density of the crown cover may radically change the character of the ground cover, and stands, although growing under these same physical conditions, but having a different crown density, would have a different ground cover, and therefore would have to be grouped into different forest types. Furthermore, in dense stands, as is the case with the sapling stage, the living ground cover often is entirely lacking. In such a case it would be very difficult to determine to which type the stand should belong. The author himself realizes that the character of the living ground cover depends upon the light conditions prevailing in the stand, the amount and condition of the leaf litter, etc., but considers them unessential. In our opinion these conditions are very essential, and to distinguish forest types on the basis of such unstable and changeable characteristics appears to us a risky undertaking. The living ground cover can furnish sufficiently exact indications of the soil conditions only in a few exceptional cases; for example, Cladonia and Calluna on dry, poor sand and thick Sphagnum in swamps. Very often plants appear to be more or less cosmopolites, and the same species is often found on most different soils and on most different situations. By combining, therefore, into one type stands which have the same living ground cover, we may group into one type stands which have different physical conditions of growth. We most heartily subscribe to Professor Cajander's conclusion that all silvicultural measures should be based on the study of forest types; not forest types classified on the basis of the living ground cover, but on the basis of the physical conditions of growth.

The author has compared the growth of stands by the basal area taken at the stump. His excuse for using the stump height was that abroad he could not use more accurate methods of determining growth. Yet in describing the forest types in his own home forest the author used the same method. The basal area taken at the stump, where root swellings often occur, does not characterize the rate of growth of the tree. The basal area in such cover depends greatly upon the height of the stump, and this in most cases is a very indefinite quantity. A much safer criterion in this respect would be the height of the tree, especially since height measurements are more accessible to an investigator in foreign countries. Another weak point in Professor Cajander's work, in our opinion, are some inconsistencies in presenting the material and sometimes evident contradiction. Thus, in the first chapter, he describes first a number of plant associations and later he indicates the factors which determine vegetation. It would seem more natural to us to reverse the order, and first to explain the causes which determine the character of the vegetation, first establish the principles of classification of plant associations and then confirm the principle by actual examples. In one place the author states that the living ground cover characterizes the physical conditions of growth, independent of the tree species; in another place, however, he shows that the tree species determine the character of the herbaceous vegetation under the trees. If in some cases the ground cover may more or less be accepted as the exact indicator of the properties of the soil and subsoil, it is hardly true that tree species themselves could influence the character of the herbaceous vegetation under them. The absence of Cladonia and heath in spruce stands is due not to the presence of spruce, but because the soil there is more fertile than in pine stands, and therefore Cladonia and heath are unable to compete with other representatives of the living ground cover. In dry pine forests, on the other hand, on poor sandy soils the pine itself, and, accompanying it, living ground cover of Cladonia and *Calluna vulgaris,* have no competitors.

It is also difficult to agree with the author that the struggle for existence leads to the formation of pure stands, and that mixed stands are an exception to this general rule. In our opinion, in nature there are more cases of mixed stands than of pure stands. The latter are formed chiefly under exceptionally extreme conditions; for instance, pine on dry sands, or pine in the swamp, etc. No matter how long the struggle for existence may continue, as long as the physical conditions of growth will suit at the same time the biological requirements of two or more species there will be mixed stands.

For American foresters the last chapter on the importance of forest types in forestry is of special interest. The viewpoint of the author is familiar to many of us, as the basis for classification of forest types is a live subject also with us. In spite of some defects of Cajander's work, we are glad to make it known to American foresters. It comes as a new argument in favor of the opinion shared by some of us, that forest types is not an idle invention, "the product of an impractical mind," but a fact correctly observed and confirmed by independent observations of foresters in other countries. Every truly practical forester will and always does take into account forest types, the biological units with which he has to deal, and which must lay at the foundation of a rational organization of his forest.

RAPHAEL ZON.

U. S. FOREST SERVICE,
WASHINGTON, D. C.

THE THEORY AND PRACTICE OF WORKING PLANS (FOREST ORGANIZATION)[1]

The Theory and Practice of Working Plans has the distinction of being the first text-book on forest organization to be written in America, and, viewed in this light, it is of considerable importance. It cannot be said that it adds very much to the sum total of knowledge of the subject, nor does the author claim for it any originality; but it is a comprehensive compilation of the different systems which have been developed in Europe, and are either being practiced there now or have been important as the foundation of the systems now in use. Heretofore a study of these systems has forced the student to search through a long list of tangled sources—German, French, and English—often couched in such technical language that they are difficult of comprehension. The collection of these scattered bits of information into the convenient compass of one small volume and their clear statement is a great aid to the student of forest organization.

The book is divided into two "parts," the first dealing with the "Foundation of Working Plans" and the second "The Practice of Working Plans." Chapter I takes up the normal forest as the basis of all forest organization. Since the normal forest has been cast for such an important part, it seems as though the analysis given of it is a little superficial. The definition of normal increment is "the increment given in yield tables," and this is followed by a rather fragmentary discussion of different methods of determining current and mean annual increments. No very definite idea of the real meaning of the normal yield is obtained. This is unfortunate, since the definition of the normal forest depends directly upon it.

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[1] By A. B. Recknagel, A. B., M. F., Professor of Forestry, Cornell University. John Wiley & Sons, New York, 1913.

Section 2 deals with reconnaissance, or the collection of data. This is one of the most complete sections in the book, and contains considerable data which can be applied directly in American practice. Some of the descriptions seem rather vague and baffling, but this feature will be taken up later on in the general résumé of the book and will not be touched in the detailed discussion of the sections.

In Section 3 the author discusses the determination of method of treatment under the three heads of (1) the unit of regulation; (2) the silvicultural method of management, and (3) the object of management. The first of these is very clearly and definitely treated. The second and third, however, are extremely unsatisfactory. Considering the purpose of the book, we should expect a rather exhaustive discussion of the interdependence of the silvicultural methods and the object of management, with, possibly, some of the examples which the author has used so frequently elsewhere. Surely this is a point of considerable importance; but we are left with a few definitions of the different silvicultural methods, which might readily be presupposed in a student who has reached the study of forest organization, just as the author has presupposed his reader's knowledge of mensuration.

There follows a list of definitions of the different kinds of rotations which possibly belong more properly to the forest valuation, but should in any event have been more closely correlated to the two preceding sections. Isolated as they are, they certainly have little bearing here, though excellent in themselves.

A discussion of the determination in the yield forms the first section of Chapter II. Here we have a really masterly piece of work, which shows great care and an enormous amount of detailed work. The author has collected seventeen different methods developed in different parts of the world—most of them, naturally, from Germany—and explained each one in detail, together with its application. The explanation is in most cases very clear—in this respect contrasting very strongly with the description in the original sources—and each one is illustrated by specific example worked out in great detail. That the example taken in every case is a 200-year rotation in yellow pine in the southwest is unfortunate, because that is probably a longer rotation than will ever be used in any other part of the United States and is apt to be discouraging to the students; but that does not impair its value as an example. This one section alone would make the book well worth while.

The next section on the distribution of the yield is very clear and complete. It sets forth very definitely the objects to be attained by this distribution and the methods of obtaining it. The following section on the regulation of yield in special cases is of particular value on account of its applicability to American conditions. The application of the others may come in time—if we do not develop others of our own in the meanwhile—but these can be applied now. The regulation of the turpentine orchards is of especial interest.

Section 1 of Chapter III describes the form and contents of working-plan document. It is very complete and of general application either here or in Europe. This is followed by outlines for working plans. Here sample outlines are given for Prussia, Saxony, and America—splendid illustrations to drive home the descriptions of the former sections. Certainly the outline for America ought to be complete, if an almost endless list of details means anything. In comparison with this, the planting plan which follows seems insignificant—a mere hint.

The last section of Part I deals with the control and revision of the working plan. The plan and form of this portion of the document is very fully discussed. It seems as though the value of the chapter might have been increased by a little fuller discussion of the matter to be recorded in this elaborate manner.

The second part of the book takes up the practice of working plans, mostly by geographic divisions. Chapter I discusses the European practice in Prussia, Bavaria, Saxony, Wurtemberg, Baden, Alsace-Lorraine, France, and Austria. The treatment is historical, following out the development of forest management in these countries and containing many of the details of practice, rather incomplete and fragmentary, but of great value. The chapter contains many data of great importance for economic reference; but it seems as though the value of these data would have been tremendously increased if a few of the results of management had been included.

In Chapter II the same historical sketch, but very much briefer, is given of the development in America. The outline used by the Federal Forest Service, printed in full, is practically a repetition of the outline given in the last chapter of the first part, with a few details and comments added. This is followed by a summary of the "forest plans" section of the National Forest Manual. A detailed definition of a working plan and its component parts and 14 pages of table forms, showing how the data should be recorded, concludes the book.

Summary

Regarded as a mere compilation of the data in regard to working plans, the book is a success and is of great value as a text-book for classes in management. The canvass of the sources has been very comprehensive; the explanation of complicated points is clear and well illustrated.

However, even with a full appreciation of these qualities, the impression left by a careful study of the book is one of disappointment, not with the material that has been included, but rather with what has been left out. The most serious criticism of what the author has given us is the rather exasperating frequency of cross-references, to which there is no key save a number or a letter, and the almost complete ignoring of America save that portion of the southwest included in the National Forests. Possibly some things are deserving of a little more weight relatively than the author has given them.

But these are comparatively small faults; one great criticism is the wealth of information which the author possesses and has failed to give us. The value of the facts that he has given us could be tremendously increased by a few intelligent comments and suggestions such as the author is so well prepared to give, but this he has in almost every instance studiously avoided.

He gives us a long list of different systems which should be discussed, correlated, and evaluated. The author could readily have done this with his intimate knowledge of the sources, but he leaves it to us, with our limited knowledge, to work it out for ourselves. This appears to us to be the gravest fault the book has, the failure to properly digest the facts set forth. It gives a tinge of superficiality which the author neither intends nor deserves. We should be given the full benefit of his studies and not merely the bare fact that he has unearthed. The same criticism will apply to his treatment of American management. The mere use of an example taken from its American forest does not show the application of that principle to American forests, nor does the unadorned outline of the working plan used by the Forest Service show with sufficient clearness the benefits to be received from the study of the methods which have been developed in Europe. The author states in his preface that "he does not pretend to set forth any original theories of forest organization;" but this does not absolve him from the duty of giving his readers the benefit of the practical ideas which he must have formed in such a thorough study of European practice—for, after all, the object of such study by American students is the possibility of applying some part of them in America.

The Theory and Practice of Working Plans will fill a long-felt want for our teachers of forestry; but it remains for Mr. Recknagel, who is admirably equipped for the work, or some one else, to write a still more valuable commentary on these same facts.

E. G. Cheyney.

University of Minnesota.

REPORT OF THE SECRETARY FOR THE YEAR ENDING DECEMBER 31, 1913

MEMBERSHIP

Twenty-one active and six associate members were elected during the year. The active membership has been decreased by the death of Mr. Plummer and the resignations of H. M. Hale and G. M. Homans.

The total membership of the Society on December 31, 1913, was 277, divided as follows:

Active	224
Associate	52
Honorary	1
	277

AMENDMENTS TO THE CONSTITUTION

Thirteen amendments to the Constitution have been adopted. The amendments embody the following changes:

Membership

1. Provision for admitting Canadian foresters to membership in the Society.
2. Extension of qualification for associate and honorary membership.
3. Increase of Admissions Committee to seven members, with power to elect new members to the Society and investigate and report to the Executive Committee on charges preferred against members of the Society.
4. Extension of power of Executive Committee, acting with the President and Vice-President, to take final action on charges against members, submitted through the Admissions Committee.

Publication

5. Provision for free distribution of publications to all members of the Society.

Dues

6. Assessment of $2 annual dues from associate members, in consideration of the receipt of Proceedings.

Elections

7. Fixing a maximum of twelve (instead of eight) weeks before the annual meeting as a time limit in submitting ballots on officers and Executive Committee to permit the vote of members abroad.

8. Delegation to the President of power to name the chairmen of the Committees on Meetings and Admissions.

Amendment

9. Limiting amendment to the Constitution to a letter-ballot.

IMPORTANT BUSINESS

Steps taken in 1912 to affiliate the Society with the American Association for the Advancement of Science were brought to a successful conclusion in 1913. This entitles the Society or any of its Sections to hold meetings at the time and place of those of the Association, and gives the benefit of representation on the council of the Association. No expense attaches at present to this affiliation.

The Society has also secured an organization membership in the National Conservation Congress, and was represented by five delegates at the Fifth National Conservation Congress, held in Washington, November 18 to 20, 1913.

The Society participated, by a subscription of $5.70, in the publication of a directory of the Washington Academy of Sciences.

By a vote of the active members the Society has endorsed conclusions prepared by the Executive Committee regarding the relation of forests and water, as outlined in Mr. Zon's paper, "Forests and Water in the Light of Scientific Investigations." This subject had been assigned to the Executive Committee in 1912, in accordance with a plan initiated in 1911 for "broadening the activities of the Society." The committee submitted four conclusions for ballot, with a minority report upon a portion of the first conclusion. The conclusions were adopted by a vote of 58 in favor of the minority report to 54 in favor of the majority report; nine members voted against the adoption of either.

The representation of the Society in the Washington Academy of Sciences was continued by the appointment of Mr. Greeley to succeed himself as a Vice-President of the Academy.

ROUTINE

One 29-page circular of biographies and three 4-page committee reports, with ballots, were distributed to active members during the year.

Ballots for the election of officers and announcements of candidates for membership under the new plan were also distributed. Self-addressed envelopes accompanied all communications requiring reply. The use of stamped "return" envelopes and of postal cards, instead of the former gray cards in envelopes, has saved both time and money. A "Montague" hand-power addressing machine, which was purchased last spring, has already saved a great amount of time. All communications to members of the Society and to the "complimentary list," and all envelopes for mailing the Proceedings to the regular mailing list are now addressed on this machine. Part of the Secretary's duties are to keep these files up to date.

E. H. FROTHINGHAM,
Secretary.

JANUARY 1, 1914.

ANNUAL REPORT OF THE TREASURER

FEBRUARY 1, 1913, TO DECEMBER 31, 1913

RECEIPTS

Balance from previous year		$649.29
Annual dues	$784.10	
Sale of Proceedings	399.30	
Sale of reprints from Vol. VII, No. 2	25.00	
Interest on bank deposit	12.93	
Refund from post-office deposit	5.00	
Redemption of printed, unused postals	1.12	
		1,227.45
		$1,876.74

DISBURSEMENTS

Printing of Proceedings	$872.22	
Miscellaneous printing and stationery	159.25	
Stenography and typewriting	31.28	
Postage	57.60	
Proof-reading	37.60	
Addressing machine and plates	54.39	
Organization membership in National Conservation Congress	25.00	
Expenses of lecture by Prof. F. R. Fairchild	22.00	
Thirty-eight copies of "Red Book," published by Washington Academy of Sciences	5.70	
Refund of dues	4.00	
Express	3.25	
Telegraph	1.63	
Exchange on check from Buenos Aires	.17	
		1,274.09
Balance on hand		602.65
		$1,876.74

ASSETS

Balance on hand	$602.65	
Post-office deposit	6.58	
Unpaid dues, 1912	12.00	
Unpaid dues, 1913	36.00	
Owed for Proceedings, Vols. I–VII	47.00	
Owed for Proceedings, Vol. VIII	129.50	
		$834.23

LIABILITIES

Printing and stationery	36.00
Excess of assets over liabilities	$798.23

S. T. DANA,
Treasurer.

Audited and found correct:
ALLEN S. PECK,
H. O. STABLER,
Auditing Committee.

FEBRUARY 16, 1914.

CONSTITUTION AS AMENDED TO DATE

ARTICLE I

NAME

The name of this Society shall be The Society of American Foresters.

ARTICLE II

OBJECT

The object of this Society shall be to further the cause of forestry in America by fostering a spirit of comradeship among foresters; by creating opportunities for a free interchange of views upon forestry and allied subjects; and by disseminating a knowledge of the purpose and achievements of forestry.

ARTICLE III

MEMBERSHIP

SECTION 1. Members may be active, associate, or honorary.

SEC. 2. Active members shall be professional foresters of achievement, whose field of work lies within the United States or its possessions or within the Dominion of Canada.

SEC. 3. Associate members shall be persons of achievement in lines of work closely related to forestry who have shown substantial interest in American forestry. They may attend all meetings of the Society and take part in its discussions, but shall not be entitled to vote.

SEC. 4. Honorary members shall be chosen from those who have rendered distinguished service to forestry either in America or abroad, and from professional foresters of achievement whose field of work lies outside of the United States and its possessions and the Dominion of Canada. They may attend all meetings of the Society and take part in its discussions, but shall not be entitled to vote.

SEC. 5. Any active member may propose names of candidates for active, associate, or honorary membership. Such names shall be submitted in writing to the Committee on Admissions, accompanied by a brief biographical sketch giving the qualifications of the candidate for admission to the Society. The names of all candidates proposed shall be referred to all active members of the Society for comment or protest at least two months before final action is taken by the Committee on Admissions. The Committee on Admissions will then decide what candidates shall be elected, six affirmative votes being necessary to admit any candidate to membership in the Society.

Sec. 6. Charges of conduct unbecoming a member may be preferred by any active or associate member. Such charges shall be made in writing to the Committee on Admissions, which shall without delay investigate them and submit its findings in writing with the evidence on which they are based to a board consisting of the President, Vice-President, and Executive Committee of the Society for final action. A vote of at least five members of this board will be necessary to suspend, enforce the resignation of, or expel the member in question.

Article IV

Section 1. The officers of this Society shall be a President, a Vice-President, a Secretary, and a Treasurer.

Sec. 2. The officers shall be elected, as hereinafter provided in Article V, Section 2, from the active members by letter-ballot at the first executive meeting of the calendar year, and shall serve one year, or until their successors are elected.

Sec. 3. The President shall preside at the meetings of the Society, shall appoint the committees hereinafter designated, and shall perform all other duties incident to his office.

Sec. 4. In the absence of the President, the Vice-President shall preside at the meetings of the Society.

Sec. 5. The Secretary shall keep the minutes of the Society, shall conduct its correspondence, shall announce its meetings, and shall be custodian of its permanent records.

Sec. 6. The Treasurer shall collect all moneys due the Society and have custody of all moneys received. He shall deposit and expend the latter only in such manner as the Executive Committee shall direct.

Article V

COMMITTEES

Section 1. The following standing committees, composed of active members, shall be elected by the Society or appointed by the President, as hereinafter specified, at or as soon as possible after each annual meeting: Executive Committee, Committee on Admissions, Committee on Meetings, and an Editorial Board.

SEC. 2. The Executive Committee shall be elected by letter-ballot, shall consist of five (5) members, and shall choose its own chairman. Three (3) members shall constitute a quorum. This Committee shall control all funds, and shall perform any other executive duties delegated to it by the Society. The Executive Committee, before each annual meeting, shall appoint a nominating committee of three (3) active members of the Society, whose duty it shall be to make not less than two (2) nor more than three (3) nominations for each of the officers, and not less than ten (10) nor more than fifteen (15) nominations for members on the Executive Committee. These nominations shall be submitted to the active membership of the Society not more than twelve (12) nor less than four (4) weeks before the annual meeting. Other nominations, if signed by at least ten (10) members and presented to the Secretary in writing at least four (4) weeks before the annual meeting, shall also be submitted to the membership on the official ballot. The candidate receiving the highest number of votes for each office, and the five (5) candidates receiving the highest number of votes for membership on the Executive Committee, shall be declared elected. The Executive Committee shall have the power to fill any vacancies occurring in its number or in any office. The Executive Committee, acting with the President and Vice-President, shall receive and act upon the written report of the Committee on Admissions, on charges preferred against any member.

SEC. 3. The Committee on Admissions shall consist of seven (7) members appointed by the President, who shall also name the chairman. As provided in Article III, Section 5, it shall consider all names proposed for membership, and shall elect only those candidates who in its judgment are qualified for admission to the Society. When any candidate is not elected, the Committee shall notify the member by whom he was proposed of this fact. Appeal from action by the Committee on Admissions may be taken to the Society by obtaining the written concurrence of one-fourth of the active members addressed to the President. The Committee on Admissions shall also, as provided in Article III, Section 6, investigate charges preferred against members of the Society, and report upon them to the President, Vice-President, and Executive Committee.

SEC. 4. The Committee on Meetings shall consist of three members appointed by the President, who shall also name the chairman. It shall select the speakers, subjects, and dates for meetings of the Society, as provided in Article VI, Sections 2, 3, and 4.

SEC. 5. The Editorial Board shall be appointed by the President, and shall consist of nine (9) members. Within this Board there shall be appointed an executive committee, one member of which shall be designated by the President as Editor-in-Chief. The Board shall decide on the regular policy of the publication. The executive committee shall consider papers read before the Society, or otherwise submitted to it, shall approve or reject them for publication, and shall transact the business necessary to that end.

ARTICLE VI

MEETINGS

SECTION 1. The Society shall hold an annual meeting, executive meetings, and open meetings.

SEC. 2. The annual meeting shall be held at a place and on a date to be designated jointly by the Executive Committee and the Committee on Meetings. It shall be for the transaction of business and for the presentation and discussion of professional papers.

SEC. 3. Executive meetings shall be open to members only, and shall be held at the call of the President, or, in his absence, at that of the Secretary. They shall be for the transaction of business and the discussion of any subject selected by the Committee on Meetings.

SEC. 4. Open meetings may be attended by members and by guests of the Society, and shall be held as directed by the Committee on Meetings. The Society may hold such field meetings as the Society or Committee on Meetings may direct.

SEC. 5. A quorum shall consist of seven (7) active members.

SEC. 6. Upon the order of either the Executive Committee or a majority of the active members present at any meeting, any question shall be submitted to the membership for decision by letter-ballot.

ARTICLE VII

AFFILIATED ORGANIZATIONS

SECTION 1. Any local forestry society or club whose membership includes two or more active members of The Society of American Foresters may petition the Society in writing, through such members, for the enrollment of the Society or Club as an affiliated organization. If, in the judgment of the Executive Committee, the membership and aims of the organization are of sufficiently high professional character, the Com-

mittee shall grant said petition and the organization be enrolled as the ....,
(Name of organization.)
affiliated with The Society of American Foresters.

SEC. 2. Affiliated organizations shall determine the qualifications for membership in them, but no rights or privileges belonging to active members of The Society of American Foresters shall be attained merely by membership in an affiliated organization.

SEC. 3. As a condition of affiliation with the Society, each affiliated organization shall, as a whole, pay the regular annual dues of $3, and shall receive one copy of all publications and communications of a public nature intended for active members. The organization shall also elect one or more of the active members of the Society, in good standing, who shall represent the Society officially and shall handle all business and correspondence between the Society and the affiliated organization.

SEC. 4. Papers delivered before any affiliated organization shall be the property of that organization and may be published in its official organ. The affiliated organization may offer for publication, in the Proceedings of The Society of American Foresters, papers of a high professional or technical nature which have not already been published. These papers shall be subject to the approval of the Editorial Board, and if not approved for publication shall be returned to the organization in which they originated.

SEC. 5. The Executive Committee shall have the right at any time to rescind the authorization for any affiliated organization and to terminate its connection with the Society.

ARTICLE VIII

SECTIONS

SECTION 1. To carry out more effectively the aims of the Society, sections may be established wherever there are enough active members to form a strong local organization. The formation of such sections may be authorized by the Executive Committee upon the written petition of ten or more active members. Only active members of the Society shall be eligible to membership in a section. A section shall be known as the ....
(Name of place.)
Section of The Society of American Foresters.

SEC. 2. The officers of each section shall consist of a Chairman and a Secretary, and such others as may be found necessary.

SEC. 3. Any section may, subject to the approval of the Executive Committee, adopt for its own government such By-Laws as it may find expedient, provided that no part thereof shall conflict with the Constitution of the Society.

SEC. 4. No money from the general funds of the Society shall be appropriated or used for the expenses of a section.

SEC. 5. Papers and discussions presented before any section shall be to rescind the authorization for any affiliated organization and to termiward a copy to the Editorial Board. The Editorial Board shall have full right to publish in the Proceedings of the Society such papers as it may approve for publication. Papers and discussions not approved for publication by the Editorial Board shall be returned to the section in which they originated.

SEC. 6. The Executive Committee shall have the right at any time to rescind the authorization of any section and to terminate its existence.

ARTICLE IX

PUBLICATION

SECTION 1. The Society shall publish such papers read before or contributed to it, and in such form as the Editorial Board shall approve.

SEC. 2. The publications shall be free of charge to all members of the Society.

ARTICLE X

DUES

SECTION 1. The annual dues of active members shall be $3 and of associate members $2. Dues shall be payable in advance upon the first day of January, except that the dues of newly elected members for the year in which they are elected shall be payable from the date of their election.

SEC. 2. Honorary members shall pay no dues.

ARTICLE XI

AMENDMENTS

This Constitution may be amended by letter-ballot, by a three-fourths (¾) vote of the members voting, provided the proposed amendments have been submitted to all active members at least four (4) weeks in advance.

PROCEEDINGS OF THE SOCIETY OF AMERICAN FORESTERS

Copies of the Proceedings may be obtained from the Secretary for 50 cents each number.

Volume I, Nos. 1, 2, and 3, 1905 and 1906. 189 pages.

NUMBER 1.—Officers and Committees for 1905.—*President Roosevelt*, Forestry and Foresters.—Constitution.—Active Members.—Associate Members.—Honorary Member.—Meetings.

NUMBER 2.—William F. Hubbard, Obituary.—*F. H. Newell*, The Reclamation Law and Its Relation to Forestry.—*Edward T. Allen*, The Application and Possibilities of the Federal Forest Reserve Policy.—*George W. Woodruff*, The Disposal of Public Lands.—*Alfred Gaskill*, Silviculture Applied to Virgin Forest Conditions.—*Albert F. Potter*, Objections to the Forest Reserves in Northern California.—*George L. Clothier*, The Great Kansas River Flood of 1903.—*J. B. Lippincott*, The Necessity for Saving the Forests on the Watershed of the Sacramento River.—*W. J. Gardner*, Results of a Rocky Mountain Forest Fire Studied Fifty Years after its Occurrence.

NUMBER 3.—Meetings in 1904-1905.—*Alfred Gaskill*, How Shall Forests be Taxed?—*E. A. Sterling*, What are the Essentials of a State Fire Law?—*Bailey Willis*, Deforestation in China.—*L. C. Miller*, Chaparral as a Watershed Cover in Southern California.—*Alfred Gaskill*, Why Prairies are Treeless.—*Raphael Zon*, Principles Involved in Determining Forest Types.

Volume II, No. 1, 1907. 129 pages.

NUMBER 1.—Meetings in 1905-1906 and 1906-1907.—Wesley Johnson Gardner, Obituary.—*R. C. Bryant*, Some Philippine Forest Problems.—*E. A. Sterling*, Striking Features of the Forest and Water Situation in California.—*Ralph S. Hosmer*, Some Forest Problems in Hawaii.—*Henry S. Graves*, Some Problems in Forest Education.—*W. D. Sterrett*, Objects and Methods of Establishing Permanent Sample Plots.—*Raphael Zon*, A New Explanation of the Tolerance and Intolerance of Trees.—*Samuel J. Record*, Forest Fire Insurance in Germany.—*W. B. Greeley*, A Rough System of Management for Reserve Lands in the Western Sierras.—*T. S. Woolsey, Jr.*, Some Government Timber Sales in the Southwest from the Practical and Technical Standpoint.

Volume III, No. 1, 1908. 124 pages.

NUMBER 1.—Program of Meetings.—Announcement.—*Herbert A. Smith*, Some Further Considerations Regarding the Tolerance and Intolerance of Shade.—*Edward E. Carter*, The Silvicultural Results of Marking Timber in National Forests.—*Henry S. Graves*, Condition of American Silviculture.—*T. S. Woolsey, Jr.*, Managing a National Forest from the Business

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of
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April, 1914

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April 2. Open Meeting. New Developments in Eastern Woodlot Problems. Bristow Adams, J. H. Foster, F. F. Moon.

May 7. Open Meeting. The National Forests of Alaska. James Barry Adams, Earle H. Clapp.

May 16. Open Meeting at Cornell University, Ithaca, N. Y. Lines of Principal Effort in American Forestry for the Next Decade. B. E. Fernow, Alfred Gaskill, Filibert Roth.

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VOL. IX APRIL, 1914 No. 2

FOREST ADMINISTRATION FOR A STATE

BY A. F. HAWES

Contributed

Dr. Fernow, in his address of July 23, 1913, before the Society for the Protection of New Hampshire Forests, outlined "A Plan Adequate to Meet Our Needs for Wood and Timber." * More than in any previous writings, Dr. Fernow in this article advocated artificial reforestation on a large scale. The sum and substance of his argument was that the States should loan money to the towns (in New England at least) to carry on this reforestation until at least 60,000,000 acres throughout the country are replanted, and that the nation should lend money to the States.

Just why Dr. Fernow believes that the ultimate expense of this work should be borne by the towns and why they should be the large forest owners is not made clear. Personally I believe that public activity along this line in New England will be much more largely through State than town ownership. Most of our mountain and hilly towns are poor and have been steadily growing poorer. Tax rates have been increased as assessable property and population has decreased. To be sure, this is an argument for reforesting and the future ownership of profitable municipal forests. Unfortunately the towns of New England are the most thoroughly democratic institutions that exist. Inasmuch as democracy in this country during its first hundred years failed utterly to provide for the conservation of natural resources and the prosperity of the future, we need not be surprised that our towns have no such inclination. Town governments, much more than either State or national governments, are managed in a hand-to-mouth way, with absolutely no regard to the future.

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* See "Forestry Quarterly," Vol. XI, No. 3, September, 1913, pp. 307-322.

There are in many towns progressive men who can see the advantage of planting forests for their children and grandchildren, but who would never agree to allow their towns to go into debt for such a proposition. After all, it may not be surprising that this conservative feeling is so common. There are not a few towns in New England today whose tax rates are excessive (from 2 to 5 per cent) because of the necessity of paying interest on war debts or railroad debts of thirty to fifty years' standing. The burden of the indebtedness for railroad construction, which never paid the original stockholders and often resulted in actual detriment to the hill towns, has been serious. Most of them feel the need of more immediate improvements, for which they would prefer to incur debt rather than for a long-time investment, which naturally seems much more risky than did their old-time investment in railroads.

While the several States are having increasing difficulty in meeting their expenses, owing to the many new governmental activities which all are required to adopt, the State treasury is not as near to the people as their town treasuries. They are, therefore, more willing to allow the use of State funds for permanent improvements and long-time investments, such as the establishment of State forests. If, therefore, any such extensive public-forest planting is done in New England as is outlined by Dr. Fernow, I believe it will be largely by the States. In order to fulfill his plan it would devolve upon Vermont, for example, to purchase and reforest about 1,000,000 acres at a total cost of $16,000,000 for purchase, planting, and interest charges. This estimate is based on Dr. Fernow's assumption that the land can be purchased for $3 an acre and reforested for $8, and his estimated cost of a 5,000-acre plantation as follows: $55,000 accumulation on loans and $26,870 accumulated interest, or a total cost in the twenty-fifth year of $81,870. Should any such extensive purchase policy be adopted the price of land would advance considerably beyond this figure. With present prices of labor ($1.75 per day in most localities) and of nursery transplants ($5 per thousand) it is impossible to plant 1,200 trees per acre for $8 except on land free from brush and rocks. Most of the land under consideration would require at least $10 to secure a full stand.

Admitting, however, that Dr. Fernow's plan is good, as an ideal toward which we may work, let us consider whether we may expect a State like Vermont to invest from $5,000,000 to $16,000,000 in forestry work during the next twenty-five years. There is a decided and, on the whole, I believe, wise conservatism among the people of Vermont regarding the

State's assuming a bonded indebtedness for public improvements, even for highway construction, which at present is the most immediate problem before the public. We have no State indebtedness, and with the present feeling it would be impossible to secure a loan for such a purpose as extensive reforestation. The policy of "pay as you go" must, during the immediate future, at any rate, be the watchword of the State forester. How much can we expect a State to appropriate from year to year in work of this kind, considering the many other lines of activity?

ANNUAL APPROPRIATION

It is impossible to forecast just how rapidly public sentiment will advance in forestry, since such advance is not regular but cumulative. I think it may be fair to assume that a present appropriation of $17,500 may be doubled in five or six years, and that within a period of ten or fifteen years it may reach $50,000. It is doubtful whether much more than this can be expected until these investments have returned substantial dividends to the State. With the most optimistic figuring possible, I cannot imagine the State of Vermont spending $1,000,000 during the next twenty-five years for forestry work.

In the following pages I propose, therefore, to outline what seems to me to be the most efficient use of an appropriation of $50,000, skipping over the intermediate appropriations, with which the department must be content for a number of years.

State Forests

The first question which will occur to any forester will undoubtedly be, "How much of this money can be spent for the purchase of land?" For reasons which I will explain later, I do not think over two-fifths of such an appropriation can be so used, or say $20,000 a year. At $5 an acre this would purchase approximately 4,000 acres a year, or in a quarter century about 100,000 acres. If at the same time $8,000 a year is used for reforesting the open portions of these tracts, about 800 acres a year can be so planted, or in a quarter century 20,000 acres.

In the acquisition of large forest tracts by the State I do not believe that it is the best public policy to expend all the money available in the purchase and reforestation of cut-over waste lands. Such a policy encourages destructive lumbering by offering a market for otherwise unsalable property. Land should be acquired with stands of different ages, and particularly lands which have been so conservatively cut that they have reproduced more or less naturally. As is well known, such property at present prices is a much better investment than waste land artificially stocked. It will begin to bring in an income much sooner, and thus help out the forestry movement at a time when its novelty has worn off and there may very likely be some opposition to it on the ground of economy. It will also make it possible to demonstrate wherever State forests are established different forestry methods which private owners may profitably adopt. In any such tracts acquired it is safe to say that at least 20 per cent of the area would be open land requiring planting. These areas would be sufficient to use all the money available for that kind of work; would furnish demonstrations of planting, and would produce the younger age classes to accompany the older, but less fully stocked age classes. A normal growing stock would be obtained much sooner than if waste land alone were secured. The individual forests should eventually be not less than 5,000 acres each in area for economy in management, though they may be started with smaller areas as tracts become available at reasonable prices and in order to furnish more numerous demonstrations.

To take charge of administration of the State forests, there should be a trained assistant at a salary of $2,000 and an assistant bookkeeper at a salary of $600. The pay-roll for planting is included in the budget for planting and that for fire prevention under "protection," described below. Traveling expenses and sundries might readily use $1,400. It may be assumed that after ten years the revenue from the forests will at least cover these administrative expenses; as the State forests are increased the growing revenue over this amount should be used for road construction. The total amount of the appropriation chargeable against State forests would, therefore, be about $28,000, the other $4,000 coming from the forest revenue.

While such a division of funds would be a permanent investment of over half of all the money available during a quarter century, only about 100,000 acres would be thus affected—a very small portion of the whole State. It may be a question with many whether the people are justified in making this investment; but any one who has studied forest history must admit that government ownership of considerable areas is the ultimate key to the situation. However, it is evidently a very slow way of bringing about forestry methods throughout a State, and there would not be justification in spending a greater proportion of the appropriation in this way.

Protection Forests

The question arises, therefore, as to how an annual sum of $22,000 can be so expended as to bring about the quickest and best results throughout the privately owned forests of the State. All will agree that the chief agent must be education. Educational methods will in a few years bear noticeable fruit in improved farm woodlots, more extensive planting, and in the management for permanent yield of tracts of considerable size by manufacturing concerns. The large lumber and pulp companies, however, owning the most extensive areas of mountain lands, have as yet, in Vermont as elsewhere, only played with forestry and foresters. Nothing can be expected of them beyond an interest in fire prevention and a closer utilization. Why a lumber company which is protecting its lands from fire should claim to be practicing forestry is beyond understanding. We should hardly consider a man a progressive farmer simply because he provided fire-extinguishers for his buildings, but persistently ruined his soil.

The denudation of these mountains has a distinctly more public bearing than has wasteful lumbering on level lands, because of the broader influence of mountain forests on water supply, stream-flow, and to a less extent upon climate. For this reason I believe that the State has the right and, failing voluntary adoption of forestry methods, the duty of regulating the cutting of forests on the mountains, considering these forests as a public utility. That this is constitutional has been given an opinion by the Supreme Court of Maine, and I believe cannot be gainsaid in the light of present progressive tendencies. Foresters have always been very backward about assuming this view. They have said that it is un-American, and that the natural way is through State ownership. Granted that State ownership is the ultimate aim, let us consider whether it can claim exclusive American rights. If we turn to other fields we find that the American people have been expressing their changed attitude by a broader interpretation of the police powers of the State rather than by public ownership. Some years ago Mr. Bryan advocated government ownership of railroads, but no important roads have thus far been acquired. On the other hand, the Interstate Commerce Commission has been so strengthened that it unseats railroad presidents, passes upon railroad rates, and in many other ways has gained public approval to such an extent that its powers are being steadily increased. Public ownership of the telephone and telegraph companies has been repeatedly advocated, but no progress has yet been made in this direction, although these companies are now subject to strict regulations on the part of the public-service commissions of the various States and of the Interstate Commerce Commission. Neither have we any public ownership of express companies, though their rates have been materially cut down by order of the Interstate Commerce Commission and by competition with the parcels post. Turning in another direction, we see how the police powers of the

State have been increased—as, for example, in the summary power given the State Board of Health, State Factory Inspector, Cattle Commissioner, and similar officers. In forestry, slash-disposal laws have been passed by such States as New York and Minnesota. While State ownership of railroads, telephone, and telegraph service, express business, and other public utilities may or may not be desirable in the end, it is obviously the American way to first control these industries. The tremendous sums necessary for purchase could not be raised by the States in the present condition of public opinion. Still it has not been thought best to allow big business to go on watering its stock, acquiring worthless properties for the benefit of inner rings, and paying most of the profits in the form of high salaries to a few large owners. Why should foresters placidly assume that until the State can buy the forests that the big lumber interests must be allowed to do their worst with the virgin forests of America? As has been already intimated, it is absolutely out of the question for Vermont, and I believe for any State, to extend the policy of purchase and reforestation fast enough to overtake the men who are so rapidly diminishing the supply.

Granted that State control is desirable, there are several stumbling blocks. The practical man will immediately say that such a bill could not be passed. I believe that a bill such as I am here advocating would pass the House of Representatives of Vermont, which is composed largely of farmers, small business men, and others directly representing the people. Whether or not it would pass the Senate, which has a greater proportion of lawyers, is a question. It probably would not pass at first, but public opinion would secure its passage in time.

Another objection raised against State control is that it will not work; that such a law would be impracticable and impossible of enforcement. If applied to the whole State, this undoubtedly would be true, but I propose an elastic plan which can be put in use only as rapidly as an administrative force is built up which can enforce the law. The Forestry Department should have the power to set aside protective forests above a certain elevation, probably 2,500 feet, and eventually steep slopes below this elevation. In this way protective forests could gradually be established at the headwaters of the important streams, and simultaneously a corps of men would be developed capable of handling them. In these protective forests it should be illegal to cut any timber except under the direction of the Forestry Department. It will be noted that this is no diameter limit law. All cutting would be under the immediate supervision of experts paid by the State. The policy of the department would be very lenient at first, gradually insisting on more intensive methods as market conditions warranted their application. The owners would not only get free expert advice, which they may in time come to appreciate, but should have special protection from fire and all possible safeguards against overtaxation. It should also be the policy of the department in purchasing forests, in so far as possible, to relieve the owners who would prefer selling at reasonable prices to managing under State control.

Very little has been written on the relative value of mature forests and underbrush as conservers of water, but investigations made by the U. S. Geological Survey prove that coniferous forests must have much more effect upon run-off than the deciduous brush that usually follows logging, because of the more gradual melting of snow under the former cover. Mr. Zon's articles have shown beyond question that the rainfall is greater at higher elevations than in the lowlands, and that at such elevations it is increased by a forest cover more than at lower levels. It therefore seems of great importance that the coniferous forests of the upper mountains in a State like Vermont should be maintained. The policy outlined above, insisting upon conservative cutting of our mountain forests, would seem to have more value as far as any present effect upon stream-flow than the policy pursued by the Federal Government of buying cut-over lands.

The area in Vermont, which might very properly be thus set aside, above 2,500 feet in elevation, for protective forests, may be roughly estimated at 200,000 acres. A technically trained assistant, with a salary of $2,000, should have charge of this division. Under him there should be a ranger, at a salary of $800, directly in charge of each protective forest or area of about 30,000 acres. Protective forests should not be established before money is available for the employment of rangers at this rate. For the total estimated area seven rangers would be needed, thus requiring $5,600. Each of these rangers should be provided with a horse. It would be their duty to patrol their forests for fire and trespass throughout the dry season; to mark or supervise the marking of timber to be cut by the owners, under instructions from the chief of the division, and to inspect the cuttings in order to see that the regulations were carried out. Of course if there were a great many cutting operations simultaneously in different parts of a large forest it would be necessary for the ranger to have help. A sum of $2,400 would be available for the employment of temporary assistants at any time of need, whether on account of fire danger, stress of cutting work, or other reason. Traveling expenses of the chief of division would also come out of this fund and such office assistance as is necessary.

Fire Prevention

This division would also have charge of fire prevention throughout the lower portions of the State. Lookout stations located on some of the protective forests would protect much of the lower surrounding country. If the United States coöperative protective work were continued, the amount paid the rangers mentioned above in protecting the navigable watersheds from fire could be charged as the State equivalent to offset the United States money, which might easily be $3,000 a year. This sum, judiciously spent in hiring patrolmen in dangerous localities and lookout men on one or two lower peaks, would provide fire prevention on the navigable watersheds. Five hundred dollars, in addition to that spent on the protective forests, would provide protection for the Champlain watershed.

The Division of Forestry Extension

The division of protection would thus require $10,500 annually of the total appropriation of $50,000. There remains but $11,500 to devote in introducing better forestry on the remaining forests of the State, which comprise nearly 3,000,000 acres. This must of necessity be done through educational methods. Were it not that the State forests will be of great educational value, and that protective forests will be a great benefit to the people and industries of the whole State, there would hardly be justification in spending four-fifths of the appropriation mostly on one-fifth of the forest area.

The division of forestry extension would be directly under the State forester, who should have an assistant, with a salary of at least $1,500, who should be an expert on marketing forest products and the grading of lumber. This assistant should make every possible effort in connection with the county agricultural advisers, the milk-testing associations, and other local organizations to organize coöperative sawmills and other manufacturing plants of small capitalization based on a proper handling of the tributary forests. Every effort should also be made to organize stock companies for timber raising, who would operate over large areas under forestry principle and would be satisfied with a return of 5 or 6 per cent on the investment at least until the normal growing stock was obtained.

At seasons when their other duties allowed, the assistants in charge of State forests and of protection should assist in addressing meetings and in holding forest conferences. In these conferences more emphasis should be placed on the field meeting and less on the lecture. By proper arrangement on the part of the county agent, one man could hold two woods meetings in a day in opposite sections of a town, with an evening meeting at the village. It should be possible in this way to hold at least one conference in every town* during the year.

The men who are employed as Federal patrolmen during the fire season should have sufficient training to take charge of the planting on the State forests in spring and fall, in seasons of little fire danger, and should be available for extension work later in the fall and winter. Six men could be so employed for a period of five months for $2,000. They should make a farm-to-farm canvass of the State, collecting and dispensing information, taking orders for nursery stock, and in every way possible stirring up an active interest among people who do not read nor attend meetings. Allowing that one town could be covered in this way by one man in a week, it would be possible with the force above outlined to cover the State every two years. A brief report on each of these calls should be sent to the forester's office, and these calls followed up from time to time by correspondence, bulletins, etc. For the State forester's salary, traveling expenses of the staff, stenographer's salary, and incidentals of the extension service would be required the $11,500 available. The spending of this amount by the State should certainly entitle the Forestry Department to at least $1,000 from the Federal appropriation for agricultural extension, under the recently passed Lever bill, which could be advantageously spent in supplementing the above work in such ways as the Government saw fit.

Such a plan as that outlined above can only be effective as it is made elastic. Men would be transferred from one division to another as occasion warranted.† For example, any State forests located in proximity to the protective forests would be handled by rangers in charge of the latter, who would take their instructions for this work from the assistant in charge of State forests. These rangers would also serve during dry weather as lookout watchmen and patrolmen in the protective forests. In the same way the regular patrolmen would be in charge of planting on the State forests and at other seasons in the extension service. State nurseries would probably in time be devoted exclusively to the raising of stock for the State forests, as private nurseries will undoubtedly be able to supply stock to private owners. The cost of running the State nurseries is, therefore, included in the above estimate of $8,000 for planting State forests.

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* In Vermont the word town is used instead of township.

† The work of the Forestry Department in Vermont is at present carried on by three divisions: (1) Management, under a graduate of the Yale Forest School; (2) Fire Protection, under a graduate of the Biltmore School, and (3) Office, under a trained stenographer and bookkeeper. Besides the supervision of these three divisions and the forestry work of the College and Experiment Station, the State forester does as much of the forest management as his time allows. In very dry weather his time is devoted to the forest-fire problem. While the divisions mentioned above are maintained most of the time, there is an interchange of men from one to the other, as conditions of weather and press of work dictate.

This plan contemplates the continuation of forestry investigations by the Experiment Station, in coöperation with the Forestry Department and the teaching of forestry in the State Agricultural College.

Tentative expenditure of an annual appropriation of $50,000 for a State Forestry Department

Salaries	State	Income from forests	U. S. funds
State forester	$2,400		
Chief bookkeeper and stenographer	800		
Assistant in charge State forests	......	$2,000	
Assistant in charge protection	2,000		
Assistant in charge extension	1,500		
Assistant bookkeeper	......	600	
Seven rangers at $800	5,600		
Temporary assistants	2,400		
Federal fire patrolmen	......	......	$3,000
Patrolmen Champlain watershed	500		
Six forestry advisers	2,000		
Special forestry instruction	......	......	1,000
State Forests			
Purchase of land	20,000		
Reforestation	8,000		
Expenses			
Traveling expenses, etc., division State forests	......	1,400	
Traveling expenses of the other divisions	3,300		
Printing	500		
Equipment, postage, etc	1,000		
	$50,000	$4,000	$4,000

RECENT ECOLOGICAL INVESTIGATIONS

BY H. DE FOREST

Contributed

It is generally profitable for workers in similar fields to compare notes from time to time. This review of certain of the recent developments in ecological investigation by botanists aims to indicate some features of this work that it is hoped may prove even more suggestive to other foresters than the writer has found them himself. Undoubtedly the greatest measure of investigative burdens in forestry are to be borne by foresters; but their best investigative results will come not alone from the devising of original methods, but as well from the adaptation of the methods of other branches of biology to the particular purposes of forestry. Within the compass of a short paper it is possible to give no more than a curtailed account. Original sources of information must be consulted for a complete exposition.

Correlation of Vegetation and Climate—Two Principles

Any consideration of vegetation enforces the conclusion that an immense complex of conditions is confronted. All vegetation is now recognized as dynamic. Where the environmental influences are such as to permit a complete succession of stages up to the highest form now known, a forest ends the series with what may be called, in a comparative sense, a stable association. It is probable that no other form presents more difficult or intricate problems than this highest type.

It is realized that the first attack on the vegetation complex should be an attempt to split it up along some primary division line. The relation of vegetation to climate has been found as satisfactory as any. Here lies a first step in resolving the material into component parts in order to facilitate work on its many formidable issues. It is difficult to see how a valid conception of forest types can ever be arrived at until this valuable early step has been successfully achieved.

Among recent methods in this first problem of the etiology of the geographic distribution of vegetation two guiding principles are to be noted. The first aims to relate vegetation to climate by measuring environmental conditions. This is attempted usually by quantitative measurements of a summation of a group of two or more climatic factors embodied in some climatic complex and the relation of this in some manner as an index to the vegetation. A variation is the use of a single climatic factor in such a way that it is bound up with the physiological activities of vegetation. Actual instances will serve to make this plain. The climatic complex that has been most used is evaporation, representing a summation of at least the three separate climatic factors of relative humidity, temperature, and wind velocity. An early attempt of this sort in this country, and one that is now recognized to have been epoch-making in its implications, although its accomplishment could be but small, was Transeau's[1] ratio of $\frac{\text{rainfall}}{\text{evaporation.}}$ This resulted in an integral index of the operation of the three climatic factors at the station where the data were taken. It is well known how, with meager data, he constructed a map showing very approximately the areas of the United States having the same rainfall-evaporation ratios, and compared this with the distribution of vegetation in the eastern portion of the country, bringing out some striking coincidences with the forest vegetation of that region.

Another investigator, Shreve,[2] has recently used a different ratio of a similar sort. He argues that it is not the actual amount of rainfall which is of importance, but the amount of soil moisture. Hence he employs the ratio $\frac{\text{soil moisture}}{\text{evaporation,}}$ claiming that this does not contain the error due to insignificant or to superfluous rainfalls forming a part of the annual total, but, on the other hand, is an actual expression of the relation of the moisture supply for vegetation to the atmospheric drain which is made upon it. He has not applied this to any general correlation of vegetation and climate, and although so applicable it is nevertheless a method better fitted probably for local rather than for regional application, and one especially suitable for use in climates with short seasonal rainfalls.

Still another investigator, Livingston,[3] has carried this principle much farther. He makes use of a combination of temperature summations (similar to those that are familiar in the work of Merriam in the construction of his life zones) and evaporation data. His method results in three charts showing temperature summation lines for the frostless season (running east-west), combined respectively with lines of equal precipitation with lines of equal evaporation, and with lines of equal differences between precipitation and evaporation (running north-south), forming thus three climatic mosaics. These charts are for comparison with vegetation maps of the United States. They bring out clearly the general correspondence of the great vegetation forms of forest, prairie, and desert with certain types of climate, but on account of the miserably inadequate data obtainable are necessarily the merest approximations. Their great importance lies in what may be possible by this or similar means when suitable stations and data are available. In another investigation Livingston[4] makes use of the single factor of temperature instead of a complex of climatic factors, but ties up this single factor with the physiological activities of vegetation through the application of the chemical principle that within limits the velocity of most chemical reactions about doubles with each rise in temperature of 10 degrees centigrade.

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[1] **See citations on pp. 174–176.**

The second of the two principles endeavors to find in the vegetation itself a summation of the effects of climate. The advocates of the former principle hold that while a vegetative organism furnishes at any instant a summation of the effects of all the processes which have gone on in its body during its previous environmental history there is an insuperable obstacle in our inability adequately to differentiate this vegetation record. The advocates of the second principle, on the other hand, hold that measurements of the environmental conditions fail because different physical factors may have the same effect on plant growth, and the influence of various combinations of factors may result in essentially the same growth form of vegetation. Thus, they say, physiological drought may arise from the widely different physical factors involved in cold and in drought. They conclude that the plants themselves must be the recorders of the biological value of any climate.

One of the most successful followers of this latter principle is the Danish botanist Raunkiaer.[5] It is, unfortunately, impossible to describe his method in detail within a brief space. The successive steps may, however, be indicated. As his basic principle he uses the adjustment of plants to the critical or rigorous season as expressed by the nature and degree of protection possessed by their dormant, perennating shoot apices. His first step is to make a classification of all flowering plants on this basis. By this means he establishes ten so-called "life-forms." Then these are applied to a correlation of vegetation and climate by a notably sane use of statistical methods. First he analyzes different types of climate by calculating the percentages of each of the "life-forms" found in them. By this means he is setting up what he calls a "phyto-climatic spectrum" for each type of climate. Of course in doing this the main object is to obtain a normal standard for each of these climatic types in order to have a sound basis of comparison for use when an investigator wishes to correlate the vegetation of some place with its climate. Ideally this normal standard would be the phyto-climatic spectrum of the whole earth. Practically it is gained by a proportionate representation. For example, the stem-succulent life-form (one of Raunkiaer's ten) is given the basis of about 1 per cent of the total number of plants he analyzed, and the stem-succulents constitute about 1 per cent of the total number of all flowering plants known. Thus approximate normal spectra for various types of climate are gained. Then for an investigator to use the method the approximate normal phyto-climatic spectrum of the appropriate climatic type is treated as a sort of base line, and the outstanding features of the spectra of different areas within that climatic region deduced by a comparison of the amount of divergence their statistics show from the normal spectrum. The method has been worked out as yet only in the frigid and temperate zones, where a tentative delimitation of certain "climate-zones," each characterized by its own "climate-series," has been accomplished. Several years of trial in the field leads Raunkiaer to the conclusion that the method furnishes a good working hypothesis.

Habitat Investigation

The complete investigation of a habitat may be said to proceed along two main lines. One of these deals with the origin and historical development of its vegetation and the other with the present environmental conditions. Eventually there will doubtless have to be some sort of systematic classification of habitats according to these environmental conditions, but the chief concern now is with the devising and developing of methods of investigation of the environments. With this latter work, however, the future necessity for the former is entitled to some attention.

Light on this point may be secured from an expansion of the idea contained in a recent paper by Crump,[6] an English botanist. An investigation of the conditions in a plant habitat, he states, practically never admits of the exact measurement applicable in physics and chemistry. Take, for example, a single complex such as the water content of the soil. If the water content of the soil of a specific variety of habitat is any sort of a constant of nature it differs, he argues, radically as such from an atomic weight and can never be stated with the same exactitude, since it is from the very nature of the case subject to considerable fluctuation. But variation from a specific type, he continues, is axiomatic in biology, and the determination of the mean or "mode" corresponding to the type is a familiar problem of biometry. Such a point of view is absolutely necessary in dealing with plant habitats. Whether it is soil-water content or some other environmental condition that is being investigated, its values for that specific habitat will show variation about a mean. If the deviations follow a normal course, supposing a sufficient number of measurements to have been made, the mean affords a definite index of this condition of the habitat, and a habitat that satisfies such a test for a number of environmental conditions is as much an entity as is a biological species. Extreme variations, Crump explains, will possess much significance, for they should indicate the physiological limits of the existence of plant associations. Above and below such limits certain plant associations will probably be unable to exist, and even before these points are reached they will doubtless have become of weakened identity.

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Aërial Environment

The evaporating power of the air[7] is now known as the master-factor, or limiting condition, in inhibiting the growth of many plants. It is, hence, often the controlling item in the determination of the plant population, and appears to play an important rôle in the determination of the vegetation which can best succeed in differing but neighboring habitats. A secondary effect, that of determining in large measure the moisture content of the soil, is perhaps usually a more important element in the distribution of vegetation than is its primary effect of changing the rate of transpiration of plants. For ecological purposes there is at present no better instrument for measuring evaporation than the standardized porous-cup atmometers.[8] Since it operates properly only during frostless periods, its work is, of course, best in localities where the growing season coincides with this period. Its evaporating surface of porcelain may be so exposed as to be fairly comparable with the evaporating surfaces of vegetation. It is really a sort of artificial plant without, of course, the plant's mechanism for regulating the water loss from the interior. It affords a direct integration of the evaporation data which it secures. The basis for investigation may be a single habitat or a comparison of different habitats; the various parts and strata of a single association or the differences between various plant associations. Within the sphere of the investigation of forest influences a wide area is opened by its use.

By means of such an instrument the English botanist Yapp[9] found the evaporating power of the air to vary, even with marsh plants about five feet in height, in the three strata of (*a*) above the vegetation, (*b*) about the middle, and (*c*) in the lower strata, in the proportion of a : b : c equals 100 : 32.8 : 6.6, and found, too, that the higher and denser the vegetation the greater these differences are. Transeau[10] found that in spite of an unfavorable exposure the partial invasion of a gravel slide by vegetation produced a 40 per cent reduction in the evaporation rate. His investigations led him to the conclusion that as reforestation proceeds, in the region of his experiments, the evaporation in the lower strata of the forest decreases from 100 per cent to about 33 per cent when the climax forest type is reached. McNutt and Fuller[11] compared the average rate of evaporation on a percentage basis through one growing season in several associations. The beech-maple forest was taken as the standard and the evaporating power of the air in the stratum just above the ground surface represented by 100. The comparison then is as follows:

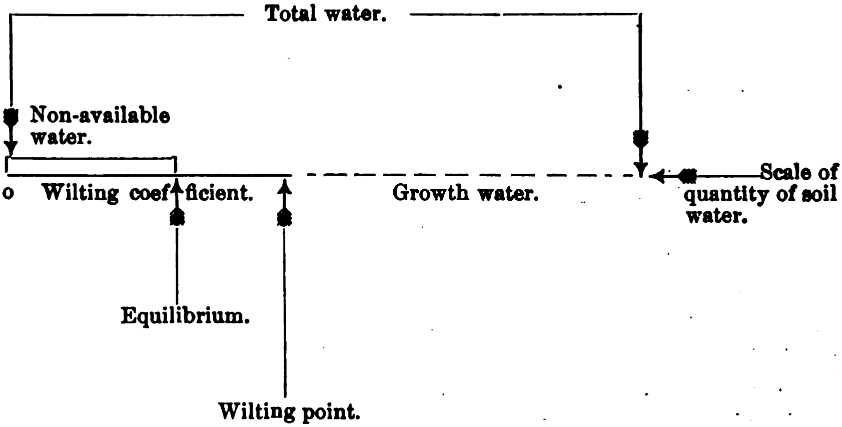
Association:	Per cent.
Beech-maple forest	100
Oak-hickory forest	115
Oak dune	127
Pine dune	140
Cottonwood dune	260

Evaporation data may be shown lucidly by means of graphs. In one graphic representation[10] the comparative evaporation rates in a number of different plant associations figure as bars of varying length. A standard, say an open gravel slide, is arbitrarily adopted. The evaporation rate for the growing season here is then taken as 100 per cent. The evaporation rates in the associations are shown by adjoining bars varying in length with their proportions of this standard evaporation for the same period. For example, the typical mesophytic forest might have a rate of only 30 per cent of the standard and would then be represented by a bar but three-tenths as long as the latter. A more detailed graphic representation[12] is that of the mean daily evaporation rates for the growing season in any stratum of a number of plant associations. This affords a graphic comparison of the march of the evaporation rate through the growing season. The time, say from May to October, is shown on the abscissa and the evaporation, in c. c. per day, on the ordinate. The evaporation rates for the different associations appear as series of lines whose abrupt changes of direction are caused by rapid alterations of the evaporation rates due to rainstorms, cloudy weather, etc., or any factor that will materially alter the rate—such, for example, as a cutting in a forest—which would appear in the graph of a station within it by an abrupt and prolonged rise of the line. Seasonal changes in vegetation also alter the rate lines in some associations. A graphic representation of this sort by Fuller of a cottonwood dune association, a pine dune association, and several others, brings out some interesting facts. Evaporation in the pine is shown to be decidedly lower and more regular throughout the growing season than in the cottonwood which it succeeds. The pine exhibits throughout rather a continuous stress than a series of violent extremes. The greatest divergence between the two appears in the early part of the season, in May and June, when the pine has an evaporation rate much less than that of the cottonwood, undoubtedly due to the evergreen character of its vegetation, giving adequate reason for counting upon the presence during the early part of the growing season of mesophytic plants and moist forest annuals whose activities are limited to the early spring. These are but some of the applications of graphic representation for spreading out the evaporation data so that facts and conclusions, based upon quantitative experimental evidence, may be more easily drawn. Considerable development in the graphic representation of such data will surely ensue. The greater part of the work already accomplished has been for distinctly botanical purposes. Undoubtedly there is room for wide application and development in the investigations of forestry.

Edaphic Environment

A recent statement of Russell,[13] an English investigator, is probably the soil classic of the moment. He says that to consider any soil in its relation to plant growth it is necessary to take into account not only the intrinsic properties of the soil itself, due to the physical and chemical nature of its constituent parts, but also the extrinsic properties impressed on it by topographical and climatic features. In other words, not only the old distinctively soil characteristics, but the conditions of broader range involved in the term edaphic must be included. An adaptation of his convenient grouping of the parts of the three-fold aspect of physical, chemical, and biological considerations may be given as follows: (1) The nature, physical and chemical, of the soil particles; (2) the character, amount, and distribution of the precipitation; (3) the position of the soil in relation to the topography, and its exposure, shading, surface, and any other factors affecting its relative temperature and water supply; (4) the depth of the soil; (5) the nature of the subsoil, especially its perviousness to air, water, and plant roots; (6) the soil flora and fauna. It may be seen at once how evaporation data can successfully be correlated with certain of the above items. In short, he concludes, the soil is very much the result of circumstances, its character being determined in part by the rock from which it was derived and in part by subsequent events, particularly the temperature and water supply it happened to obtain; in other words, the soil climate, a given set of mineral particles being able to give rise to soils wholly different in value and in natural flora.

A constructive investigation that may lead, in the sum total of investigative work which it has initiated, to some of the most important results in modern ecological investigation is that of Briggs and Shantz on the wilting coefficient.[14] The amount of water in any soil is usually expressed in terms of per cent of dry weight. A soil with 8 per cent of moisture may not, however, give up water as readily as another soil with only 2 per cent. A clay may have more water in it than a sand soil and yet be drier than the latter, so far as plant growth is concerned. Hence it is necessary to determine the capacity of a soil to retain or give up moisture. This has been done by Briggs and Shantz in terms of what is called the moisture equivalent (the percentage of water which a soil can retain in opposition to a centrifugal force of 1,000 gravities). Then the wilting coefficient, or the residual moisture content of the soil (in per cent of dry weight) at the time when the leaves of a plant growing in it undergo permanent wilting as a result of a deficiency of the water supply, equals $\frac{\text{m. e.}}{1.84.}$ The figure 1.84 is the mean ratio of their moisture equivalent determinations to their wilting coefficient determinations for all the soils examined in their experiments. Their investigations led them to conclude that this ratio of $\frac{\text{m. e.}}{1.84}$ applied to any soil *is a constant for all plants growing in that soil mass*—that is to say, use *any* plant as the indicator in the determination for a soil, and for that soil mass the wilting coefficient will always be the same. A consideration by means of a diagram will make this clearer and bring out the precise meanings which this investigation has effectuated in several terms describing the water contents of soil:



"Maximum water" is the quantity present in a soil when it is saturated, while "total water" is the quantity present at any time, irrespective of saturation. An important detail appears to have been sometimes overlooked in the past. This is that when a plant is using soil water a point will be reached beyond which the plant cannot get water for its growth, yet the plant can and does go on taking up water from the soil, *even* *though the plant may have become wilted or actually dead,* and continues doing this through its tissues until another point is reached where an equilibrium is established between the soil moisture and the air moisture. All the water of the soil that has been used up to the first of these two points—that is, up to where growth ceases—is now known as "growth water,"[15] while all the water of the soil that is left in it after the second point is reached, where the equilibrium is established, is known as "non-available water." "Non-available water" is, hence, now soil water that the plant *cannot get,* while by the old concept it was often water that was not available for growth. Since the old concept of "available water" was either equivocal or incorrect, one should now, when he wishes to use the term "available water," specify what it is available for. Briggs and Shantz's "wilting coefficient" is all the water left in the soil after the "growth water" is used, or the "total water" minus the "growth water."

It is essential to realize that Briggs and Shantz's conclusion that the amount of water remaining in a soil when a plant grown in that soil reaches a permanently wilted condition is, within reasonable limits, practically the same whether the plant is a hydrophyte, mesophyte, or xerophyte, or an herb, a shrub, or a tree, applies to *one soil mass.*[16] It does not mean that plants of different growth forms, say herbs and mature trees growing together, will suffer equally as the soil moisture becomes reduced. The herbs will be tapping by their root distribution one soil mass, while the mature trees by their deeper root distribution will be tapping a different soil mass. In the matter of what soil moisture these plants can get for growth, it must not be assumed that the two general soil masses situated at such different levels are necessarily of the same constitution. They may be so, but in some cases they may differ so much that they might almost as well be soils in two entirely different situations. The wilting coefficient of the soil mass the herbs are tapping may be past the permanent wilting point, while the soil mass the trees are tapping may still have a supply of soil moisture adequate for their growth. Hence determinations of the wilting coefficient must be correlated with strata of soil comparable with the main root distribution of particular growth forms, or with juvenile and adult root systems of the same form when these are notably unlike in distribution. The wilting coefficient for tree seedlings may in some soils be very different from that for mature trees growing in the same habitat. Even tree seedlings of the same age, but of different species and different root systems, tapping soil masses less than a foot apart, may require separate determinations of the wilting coefficients of their respective soil masses, since the early seedling stage is the critical period in their establishment. Further, it is to be remembered that the wilting coefficient is not meant to apply to the type of wilting occasioned when delicate or easily wilted plants are transported to an atmosphere which abruptly gives them extremes of heat or cold or humidity, as these extremes will then produce wilting quite independently of the amount of soil moisture present. In case one accepts the conclusions of the Briggs and Shantz method, the general procedure would be to reduce determinations to a basis of soil moisture above and below the wilting coefficient for the requisite soil masses, on the ground that this affords the best data as yet obtainable for this habitat factor. It furnishes a manner of distinguishing and classifying soils that for ecological purposes is greatly needed, giving as it does one numerical figure to characterize each soil as to its soil moisture possibilities for the growth of vegetation.

The chief stumbling block to the unqualified acceptance of this method is, of course, the fact that its conclusion traverses the commonly accepted view that plants of different type differ widely in their ability to reduce the moisture content of the same soil mass before they become permanently wilted in it. All of the Briggs and Shantz experiments were conducted under carefully maintained uniform conditions, and indeed it is not known experimentally as yet *what the range of atmospheric conditions is* under which their conclusions may be expected to hold. Those who differ[17] from these investigators point out that the use of a living plant as an indicator of soil conditions leads to error unless carried out with very low evaporation rates or unless the atmospheric conditions, so far as they are related to the removal of water from plants, are clearly defined in connection with all soil-moisture determinations.

Some examples from the work of Fuller[18] will show the application of the wilting coefficient method:

1. Dune sand (pine dune association):	Per cent.
Wilting coefficient	1.05
Growth water (average for July and August)	1.04
Average total water	2.09

That is to say, when this soil contains 2.09 per cent of its dry weight of water about half of it is available for plant growth, the wilting coefficient of 1.05 per cent being a constant:

2. Clay soil (oak-hickory association):	Per cent.
Wilting coefficient	8.50
Growth water (average for July and August)	4.40
Average total water	12.90

3. Clay soil (beech-maple association):

Wilting coefficient	**11.15**
Growth water (average for July and August)	**7.50**
Average total water	**18.65**

The per cent of total water means nothing, of course, until the wilting coefficient is also known. Suppose there was 8 per cent of total water in the three cases. In examples 2 and 3 there would then be no growth water at all (the three wilting coefficient figures being constant quantities for the soils). Yet if there were a beech-maple forest on the dune sand of example 1 a total water of less than 8 per cent would still afford sufficient growth water to support there this plant association. The wilting coefficient determinations here were, of course, correlated with the soil masses in which the main body of roots grew.

If a record of the total water of a soil mass for the growing season has been obtained and the wilting coefficient for that soil mass (a constant quantity) is known, the relation of the soil moisture and the vegetation for this period may be expressed graphically.[10] The time, say the growing season from May to October, is shown on the abscissa and the total water in per cent of dry weight of soil on the ordinate. From the wilting point on the ordinate a straight line is drawn across the graph parallel with the abscissa to represent the constant wilting coefficient line. Then the data for the growth-water curve is plotted and the points connected. This gives a curved line, rising and falling irregularly, proceeding across the graph from a point on the ordinate above the wilting coefficient line. Whenever such a curve drops below the wilting coefficient line it indicates a point where permanent wilting of the plants growing in that soil mass will occur. But this term "permanent wilting" is a laboratory one, meaning that the plants cannot recover their turgidity if placed in a moist chamber *without the addition of water to the soil.* In nature this addition of water to the soil is furnished by rains. The irregular fluctuations of the growth-water curve are, hence, due to showers, prolonged rains, and dry periods.

When, therefore, a growth-water curve drops below the wilting coefficient line, it does not indicate more than a period of stress, provided the curve rises above that line again within a reasonable time. If the time is greatly prolonged, as in severe droughts, different growth forms will succumb successively, beginning with herbaceous vegetation, while the mature tree forms will usually show great resistance. Graphs such as this may also be constructed for purposes of comparison between different plant associations, and in this case some one association, say the beech-maple forest in the eastern United States, would be used as a standard.

A tabular presentation by Fuller[20] of wilting coefficients and growth water in several plant associations exhibits the difference in magnitude of the wilting coefficients, due largely to the accumulation of humus, and furnishes some valuable integrated summations of growth water in comparing these associations. He has considered the two soil depths of about 3 and 10 inches (7.5 and 25.0 cms.) as being the critical depths for the establishment of tree seedlings, and he limits his comparisons to the period of possible stress during the growing season, taking the arbitrary limit of the ten weeks from the latter part of June to the first of September. The desirability of having such data include determinations from deeper soil strata makes his conclusions somewhat provisional, as he recognizes, yet does not detract from their present value:

Wilting coefficients and mean percentages of growth water in various associations during the ten midsummer weeks (of 1911–1912)

Association.	Depths in cms.	Wilting coefficients.	Growth water.				Ratio between evaporation and growth water.
			1911.	1912.	Mean.	Comparative amounts.	
Cottonwood dune.....	7.5	.80	2.2%	1.8%			
do..............	25.	.80	2.6	2.0	2.15%	49	11.70
Pine dune woods......	7.5	1.10	.9	.7			
do..............	25.	1.00	1.7	1.3	1.15	26	10.70
Oak dune woods......	7.5	1.10	1.4	1.4			
do..............	25.	.90	.8	1.5	1.27	29	9.37
Oak-hickory	7.5	9.00	3.2				
do..............	25.	9.50	3.3	.....	3.30	75	2.78
Beech-maple	7.5	13.50	5.5	5.0			
do..............	25.	9.50	3.0	4.0	4.40	100	1.81

Fuller summarizes after the following manner: The relatively large supply of growth water in the cottonwood association is due to the conserving action of a dry mulch maintained by the action of wind upon the sand, and also to the small quantities of soil moisture removed by the sparse vegetation. In the pine association the accumulation of humus has increased the wilting coefficient. This is, however, an association in which the growth water fails repeatedly, owing to the comparative absence of a dust mulch and to the much greater demands made upon the soil moisture by the denser stand of vegetation. There is, nevertheless, a plentiful supply during the spring months, and, because of the evergreen character of the vegetation, evaporation during this season is much reduced. The oak association is an open one also and presents conditions more or less similar to the preceding. The oak-hickory association has a clay soil, with an admixture of gravel, and striking differences in its water-holding capacity are shown. Much more mesophytic conditions are represented. The beech-maple association shows a still greater advance in mesophytic conditions. The sixth and seventh columns afford some valuable comparisons. The beech-maple association is taken as the standard and its mean growth water represented by 100 (column six). In the five associations that form this succession the mean growth water forms a progressive series, with the exception of the cottonwood association, the most mesophytic having the greatest amount. The special reason for the exception of the cottonwood association has already been pointed out. From column seven another comparison may be made. Here is represented the ratio between the average mean weekly evaporation rates for the ten weeks of midsummer for the two years and the mean growth water for the same period. Although these units of measurement are not strictly comparable, the comparison instituted is a legitimate one of the mesophytism of these habitats. The data are limited to the lower stratum of the aërial and the upper stratum of the subterranean vegetation; but these are the critical points in the establishment of the associations, because in them both the herbaceous and woody seedlings develop. An extension of the data by the addition of higher aërial strata and lower subterranean strata would no doubt decrease the steepness of the gradient between the various ratios. These ratios may be compared directly, as in column seven, where the mesophytism of the various habitats varies inversely with the numbers expressing the ratios, or the beech-maple association may be taken as the standard and represented by 100 when the mesophytism of the oak-hickory, the oak, the pine, and the cottonwood associations will then be represented respectively by 65, 20, 17, and 15. Fuller concludes that these figures show such a surprising rate of increase from the pioneer to the climax association that this change in water conditions must be one of the chief, if not the most important, cause of the succession. In the interesting application of the wilting coefficient exemplified in column seven Fuller argues that the evaporation rate during the growing season shows the demand the atmosphere is making upon the vegetation, while the growth water for the same period shows the soil moisture available for growth. Consequently the ratio $\frac{\text{evaporation}}{\text{growth water}}$ is an index of the possibilities of a habitat for vegetative growth. In connection with this new ratio it is interesting to compare Shreve's[2] ratio of $\frac{\text{soil moisture}}{\text{evaporation}}$ and Transeau's[1] ratio of $\frac{\text{rainfall}}{\text{evaporation.}}$

Another soil moisture constant has been devised by Crump[6] for use in humus soils, although it may possibly prove applicable also to soils with large quantities of colloidal clay. The principle of this investigator, who worked with English peat soils, is that humus, acting as a colloid, holds practically all of the water in a humus soil—so much so that even with relatively small humus contents the water-holding power of the non-colloidal soil constituents may be neglected. His constant is called the "coefficient of humidity," and is expressed by the ratio $\frac{\text{water content}}{\text{humus content}}$ in which the total water is used. It is probably of limited application.

Scientific Investigation

One cannot long consider other lines of biological investigation than that of forestry without having further enforcement of what has come to seem a pertinent reality to many foresters. The only permanent base on which successful forest production can rest securely is that of scientific research. In ultimate analysis this signifies that much of the investigative work of forestry must be removed from any necessity for having a direct practical result attached to it. While it is true that a large part will bring direct results, some of it never can have that direct attachment to utility and must depend upon the indirect advantages it yields—that is, upon being used as the basis from which further advances may be made in the hope that from them direct practical results will be forthcoming. Many forestry problems are so intricate that their only hope of purposive solution lies in this roundabout attack. For the method of accomplishment it would seem that sooner or later, whether of private foundation or established by the Federal Government, there will have to be a Forest Research Laboratory concerning itself with the scientific investigation of the problems underlying forest production and using for its working field the forest land of the country.

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THE USE OF YIELD TABLES IN PREDICTING GROWTH

BY E. E. CARTER

Contributed

The following discussion applies chiefly to pure unthinned stands of New England white pine. Such stands occur, with very rare exceptions, only on abandoned fields and pastures, and are usually even-aged, as the term is commonly used, although the reproduction period may be ten years or more, equal to one-fifth of the financial rotation. Yield tables for such stands have been made by Margolin, working in southern New Hampshire, and by Cook in Massachusetts, both "normal yield tables." In attempting to use them for predicting the growth of stands on and near the Harvard forest, certain difficulties were encountered and views developed which may be of interest.

There have been surprisingly few discussions of the nature and use of yield tables in forestry literature in English. Schlich (3d edition, Vol. III, p. 94) states: "By a yield table is understood a tabular statement which gives the course of the development of a wood from early youth up to a certain age, either from year to year or for intervals of a certain number of years." His discussion of the use of yield tables is in accordance with this definition. American writers have seldom used the same phrases. Most discussions in this country have been based on Professor Graves' "Forest Mensuration," in which the following statements may be found on pages 316 and 318: "A yield table is a tabular statement of the yield per acre at different periods of a forest of a specified character," etc. And "normal yield tables show the average maximum yield which results on an area fully stocked by planting or natural seeding and undisturbed during the stand's life." These statements do not give a clear definition, but leave one in some doubt whether the "course of development" idea is included or not. In the discussion of yield-table construction, however, the inference is plain that it is included, for on page 322 we find, "The most satisfactory results are obtained by taking repeated measurements at intervals of about five years of permanent sample plots. We require, however, yield tables at once and cannot wait. * * * Therefore, a large number of sample plots are measured in normal stands as they are today, and from them yield tables are constructed."

This conception of a yield table as a review of the development of the stand seems to the writer to be unjustified for tables constructed by the

Baur method, as has been the case in America almost without exception. In making yield tables there is no way in which past history of the stands on the selected plots can be determined. The criteria of fully stocked plots are maximum yield and maximum basal area for the age when the measurements are taken. We have no *proof* that a stand which at 50 years of age fulfills these requirements also fulfilled them 20 years ago. Therefore, a yield table constructed by the Baur method can claim only to show for each age average maximum yields attained by stands then fully stocked. Additional data are necessary not only to prove that the yield table traces the only conditions under which a stand may attain maximum yields, but even to prove that stands do develop in accordance with the figures given. In the latter case, however, the lack of proof does not prevent acceptance. No one can question in seriousness that a stand once fully stocked will remain fully stocked or overstocked, barring accidents. But the idea that maximum yields are obtained only from stands which have had maximum yields, basal areas, etc., throughout their lives can be challenged on both theoretical and empirical grounds, although it is indicated by the directions for use given by Professor Graves on page 321: "The forester estimates the degree of stocking and assumes that the ratio of the stocking to the normal will be the same at maturity as now." If it can be shown that this ratio is not constant, the method of using normal yield tables for predicting growth must be modified.

The production of wood in a stand is controlled for any site by the amount of light absorbed by the leaves of the trees. Thus maximum wood production at any period in the life of a stand requires maximum crown density for the species. If this maximum crown density is secured early, the elimination of the smaller, weaker trees begins at once, with the loss in the final yield of the wood they have previously formed. The natural or artificial thinning of the stand removes the wood produced by part of the total amount of light that has fallen on the area, and the effect is the same as if that amount of light had not been used by the leaves. For example, if we accept Margolin's yield table* for white pine as tracing the history of a crowded stand, we find that 1,920 trees which shared in the canopy at 25 years drop out by the time the stand is 50 years old, and the wood they formed before and after the age of 25 is lost to the final yield. If this dense stand had been thinned—had had these 1,920 trees cut out—at 25 years, there would have been a waste of light due to breaks in the canopy for some years after the thinning, and so less weight and volume of woody material would be formed than if the canopy had been left complete; but there would be present at least as much volume at 50 years after the canopy was again complete as if the crown cover had been undisturbed.

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* Since this paper was written the data on which Margolin's yield table were based have been rearranged by Frothingham and a new table compiled (U. S. Dept. of Agriculture Bulletin No. 13, "White Pine under Forest Management"). The changes are in quantity and not in form, except that height of the dominant trees has been substituted for average height. For example, if the new table were used, the loss in numbers would be 707 instead of 1,920 trees.

The logical conclusion of this line of reasoning is that a stand can be expected to contain the maximum amount of wood possible for the site, species and age whenever the crown canopy is complete for the species, irrespective of crown conditions prior to that time. In considering future final yields the present crown canopy is not the proper basis for judgment, but the probable canopy at or before the final age. Full stocking should, therefore, mean that the stand will have maximum density of crown canopy at the final age, whether it has it now or not.

That the foregoing theory has some basis of fact is obvious in New England white-pine stands. It is fairly easy to find stands of financial maturity (50 to 60 years) which have yields equal to those given in Margolin's table, but which by their present appearance could not have fulfilled yield-table requirements when young stands. For instance, a plot taken in a 50-year-old stand near the Harvard forest had a volume of 51,900 board feet per acre, over 99 per cent of Margolin's yield for the age on Quality I sites, and a basal area of 242 square feet—97.5 per cent of yield-table figures. This yield, however, was obtained from 264 trees, of which only eight could be classed as overtopped, and a careful inspection showed evidence of only 44 trees that had been killed out, and a pine of any size does not completely disappear in less than 20 years after its death. Margolin's yield table calls for 430 trees at 55 years and for 1,250 trees at 35 years, when this stand had not over 308 live trees. The presence of semi-tolerant young hardwoods—now being shaded out—and the spacing of the trees shows that there must have been numerous gaps in the crown canopy 20 years ago, and therefore maximum yield for that age could not have been present.

The recurrence of instances similar to this illustration led to an investigation of the field conditions under which maximum yields are secured in New England white-pine stands. Nearly 150 plots in pure even-aged stands on and near the Harvard forest were carefully measured and estimated. So far as possible, these plots were located on what appeared to be Quality II sites, but the figures show that some plots were of the other two qualities. No attempt was made to confine the plots to stands fulfilling yield-table requirements. On the contrary, plots were taken in stands of varying densities of crown cover, and of even more widely varying numbers of trees per acre.

On working up these measurements, it appeared that there existed for each age class a fairly clear relation between the number of living trees per acre and the average basal area, or average diameter, whenever there were enough trees to form what could be called a stand. To develop this relation, curves for average diameter breast high (obtained from average basal areas) were drawn for each age class, but were not correlated. The resulting tables show for each age class a steady diminution in average diameter, with increase in number of trees per acre. The next step was in the nature of a test, and is admittedly open to criticism for mathematical accuracy, since it involved the computation of the board-foot volumes per acre by multiplying volume-table values for trees of the various average diameters by the corresponding number of trees, assuming Quality II yield-table figures for height. In other words, the mean sample-tree method of computing volumes was applied on paper as a test, although the danger of its use with the board-foot unit of measure was realized. The results of these computations are given in Table 1:

TABLE 1.—*Relation of average diameters and computed volumes to number of trees per acre*

Harvard Forest, Petersham, Mass. Pure white-pine yields. Quality II sites

Number trees per acre.	Age—Years							
	35		40		50		60	
	Average diameter, inches.	Computed volume, board feet.	Average diameter, inches.	Computed volume, board feet.	Average diameter, inches.	Computed volume, board feet.	Average diameter, inches.	Computed volume, board feet.
150...	11.8	12,470	13.3	17,100	14.7	31,800	15.1	39,850
200...	11.0	14,700	12.2	19,600	13.4	35,000	14.2	46,700
250...	10.3	16,275	11.2	21,800	12.4	38,600	13.1	49,470
300...	9.8	17,760	10.4	22,680	11.5	37,875	12.0	49,300
350...	9.2	17,905	9.7	23,030	10.7	37,845	11.2	49,700
400...	8.7	18,860	9.1	22,960	10.1	38,240	....	......
450...	8.3	19,500	8.6	23,200	....	......	....	......
500...	8.0	20,250	8.1	23,050	....	......	....	......
550...	7.7	20,700	7.7	22,900	....	......	....	......
600...	7.5	21,450	....	......	....	......	....	......
Margolin's yield table								
1,250...	5.35	*18,050	....	......	....	......	....	......
870...	....	......	6.7	*25,000	....	......	....	......
510...	....	......	....	......	9.1	*37,800	....	......
380...	....	......	....	......	....	......	10.7	*47,400

* Yield given in table not computed.

This test furnished a clue to the real situation. In so far as it can be accepted, it indicates that stands less crowded than those measured in constructing Margolin's yield table reach maximum crown density, and consequently yield-table volumes if they have not less than 300 well-spaced trees per acre at 40 years of age, 250 trees at 50 years of age, and somewhat less than 250 trees at 60 years of age. More trees give a reduction in average diameter sufficient to keep the board-foot volume approximately the same. If field results confirmed this somewhat dubious test, a standard for judging stocking in predicting yields was available, and a much more simple and easily worked standard than the comparison of present basal areas and volumes with yield-table figures. In fact, computation of the total basal areas for the theoretical stands in Table 1 raised doubts as to the validity of this standard except for the 40-year age class, for with an increasing number of trees the total basal areas continued to increase after the indicated board-foot yield had become stationary. In the 40-year class the fact that the volume table gives values for the 50-foot height class, which happen to follow closely the formula $.7D^2$ from 7 to 16 inches, inclusive, makes it obligatory that the board-foot volume and basal areas should be proportional in such computations as this. In the 50-year age class, however, the total basal area for 250 trees with an average diameter breast high of 12.4 inches is 210 square feet, for 400 trees with an average diameter breast high of 10.1 it is 222 square feet, and the yield table calls for 510 trees and 228 square feet, although according to the computations the board-foot volumes are just about the same.*

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* A comparison of the board-foot volumes given by Margolin's white-pine volume table for the 60-foot and 70-foot classes with the squares of the diameters or basal areas shows how these variations are possible. The board-foot volumes expressed in terms of D^2 are as follows:

Diameter breast high, inches.	Height class.	
	60	70
	Formulæ for board-foot volumes.	
6	$.75D^2$	$.81D^2$
8	$.83D^2$	$.97D^2$
12	$.87D^2$	$1.05D^2$
16	$.90D^2$	$1.08D^2$
20	$.95D^2$	$1.09D^2$

This also furnishes a compensating factor for the loss, in stands with late closing crown canopies, of a portion of the total wood formed, due to the development of large unusable limbs.

The real test was yet to be made. The number of plots in any one age class and of site Quality II (the latter as evidenced by height chiefly or entirely) was not great, and these few plots were subject to some little variation within the quality and age class. However, the stands in each 5-year age class were put in 50-tree groups and the board-foot volumes within each group were averaged. There were sufficient plots only to give averages worth considering in the 35, 40, and 50 year age classes. Most of the plots in the 45-year class belonged in Quality III, according to height and yield.

TABLE 2.—*Tabulation of average board-foot volumes in relation to number of trees per acre*

Harvard forest, Petersham, Mass. Pure white pine. Quality II sites. Uncurved

35-year age class

Group number trees.	Plots number.	Average number of trees.	Average volume, board feet.	Average height of dominants.
150..............	2	156	10,310	45
200..............	3	197	13,150	40+
250..............	1	256	14,000	40
300..............	5	306	18,160	45
350..............				
400..............	2	378	18,480	45
450..............	1	440	18,020	45
500..............	1	480	18,466	45—
550..............	1	532	20,700	45
600..............	3	607	20,020	45—
Yield table.......	..	1,250	18,050	45

40-year age class

150..............	4	159	17,900	51
200..............	4	205	20,160	50
250..............	5	250	20,700	50
300..............	10	294	23,060	51
350..............	*4	357	25,800	53
400..............	8	401	24,450	52
450..............	6	434	24,700	49
500..............	†2	506	23,650	48
550..............	†2	540	23,720	50
Yield table.......	..	870	25,000	52

* Age of all four plots slightly over 40.

† One plot a low Quality II.

50-year age class

Group number trees	Plots number.	Average number of trees.	Average volume, board feet.	Average height of dominants.
200..............	5	197	34,700	62
250..............	4	249	39,800	67
300..............	2	296	36,810	63
350..............	1	328	41,400	65
400..............	2	390	36,170	*60
Yield table.......	..	510	37,800	65

The data for the 55 year and the 60 year age classes while not used have many points of interest.

55-year age class

Group number trees.	Plots number.	Average number of trees.	Average volume, board feet.	Average height of dominants.
100..............	1	120	34,860	70
150..............	2	145	35,640	70+
200..............	4	202	42,700	70
250..............	8	251	45,580	75—
Yield table.......	..	430	42,550	71

Stands 60 years old are rare in the vicinity of the Harvard forest, since most lots are cut before reaching that age. One lot was found, however, where the stands answered the age and quality requirements. The average height closely approximated 76 feet throughout. Five plots were taken in it, for which the total basal areas and the number of dead trees are given as well as the other data, since these plots are excellent illustrations of the general problem discussed. The basal areas are not in the same proportion as the yields—

$$\frac{42{,}500}{47{,}400} = \frac{183}{204} \text{ and } \frac{42{,}500}{49{,}840} = \frac{183}{214}$$

60-year age class

Number of trees.	Board-foot volume.	Total basal area.	Number dead.
136.................	39,200	175	24
140.................	42,500	183	44
142.................	41,320	180	24
176.................	45,830	208	20
244.................	49,840	231	64
Yield table, 380.................	47,400	236	

The number of plots in any one age class is small—the 40-year age class, with 34, has the most—but there are sufficient for rough curves. A comparison of the volumes indicated by these curves with the computed volumes given in Table 1 proves interesting.

TABLE 3.—*Comparison of yields from plots with yields computed by mean sample-tree method*

Harvard forest, Petersham, Mass. Pure white pine. Quality II sites

Number of trees.	Age class.					
	35		40		50	
	Average, actual.	Computed.	Average, actual.	Computed.	Average, actual.	Computed.
150	10,000	12,470	18,000	17,100	*31,000	31,800
200	13,000	14,700	20,000	19,600	35,000	35,000
250	15,000	16,275	22,000	21,800	38,000	38,600
300	18,000	17,760	23,000	22,680	38,000	37,875
350	18,000	17,905	24,000	23,030	38,000	37,845
400	19,000	18,860	24,000	22,960	38,000	38,240
450	19,000	19,500	24,000	23,200		
500	19,000	20,250	24,000	23,050		
550	20,000	21,450	24,000	22,900		
600	20,000	21,450				
Yield table	18,050		25,000		37,800	

*Curve prolonged.

It should be noted that in the 40-year age class, for which the most plots are available, the data do not permit the curve to slope after the minimum number of trees for complete crown canopy has been reached, although the yields are less than that called for by the yield table. It is believed that more data would show the same condition of constant volumes with large numbers of trees to be true for the other age classes.

The results obtained appear to justify the use of number of trees likely to survive to final age as the test of density in New England white-pine stands. If, for example, an abandoned pasture has well scattered over it more than 300 seedlings or small groups of seedlings, say 10 years old, per acre, the volume may be expected to approximate yield-table figures for the quality of site when the stand shall be 50 years old, and the *final* board-foot yield will not be materially increased as a result of further thickening of the stand. In such a case the expense of planting would have to be justified by prospective returns from thinnings or by prospective value increment from better quality. It would probably be possible to fix a maximum as well as a minimum limit to the number of trees which will give the largest board-foot volume at a given final age in unthinned stands, particularly for such species as lodgepole pine or for very tolerant species, since too dense crowding is known to reduce wood production as well as to keep many trees below merchantable diameters.

In the foregoing discussion no mention has been made of the influence of full stocking, as the term has been used in the past, on the quality and value of the material produced. With most dicotyledonous species of trees, stands densely crowded from early youth are necessary for the development of stems usable for saw timber, and the production of the maximum board-foot volume involves the forms of the trees as well as the sum of their cubic volumes. Therefore there can be no problem of high yields from stands open in early youth, and the present discussion does not apply unless the yields are to be in cordwood. With conifers, also, wherever good quality is necessary to make the lumber merchantable, growth in usable volume is a function of close crowding as well as of the utilization of light. Actual work in predicting yields for young coniferous stands, however, is largely in regions where there is a market for knotty boards for containers or other uses for which hardwood lumber is unsuitable, or where if this condition does not now prevail such a market is almost certain to develop before the young stands reach maturity. Under such conditions the relation between board-foot and cubic contents of coniferous stands is more a function of size of the trees than of their form, for twists, forks, and large limbs are not so common, even in fairly open stands, as in hardwoods. High yields in value as a result of good quality are dependent largely on growth in dense stands; but the forester is confronted by stands which lack sufficient density to give high quality more often than otherwise, and if his use of yield tables is restricted to stands which will yield the largest amounts of the best quality he will use them seldom.

As a matter of fact, the estimate of quality is independent of the estimate of volume in determining either present or future yields. A forester can make a good guess at the quality of the material that will be produced, be it good, bad, or medium, from the appearance of the stand before him, but he needs whatever help is available to predict amounts with confidence. The grade of the product often controls the profit or loss of holding or growing timber, but its determination is distinct from that of volume, and yield tables commonly give only the latter. If more is given the application can be only to limited conditions of growth.

Similarly the cost of logging is an important consideration in determining the value of a stand, but in estimating it the volume to be logged is determined first. It may be noted incidentally that when maximum volume is present the cost of logging should not vary much with different numbers of trees per acre. The less weight and smaller number of logs to be moved per thousand board feet should nearly if not quite compensate for the extra limbing and swamping costs in the stands with fewer trees.

That estimates of future yields in quality and quantity are often based on distinctly different considerations may be illustrated by analyzing quality production in second growth white pine. This conifer prunes itself so slowly in pure stands that it is almost impossible to secure clear lumber within the limits of a financial rotation, as is also the case, according to Gallaher, with western yellow pine. In New England white pine quality production is obtained either through the action of hardwoods in mixture, which is a different problem from that considered here, or from long internodes, which is a function of site, or by having trees of sufficiently large diameters so that wide boards can be sawed out. In using a yield table for predicting future volumes, these factors would be considered separately from the question of amount.

The writer holds no brief for short rotation, the open stand, or the wide-spaced plantation. It is to be regretted that much of the natural reproduction of our conifers is in stands too open to make good quality production possible; but it is the business of the forester to point out the possibilities of these stands when handled under ordinary commercial conditions, as well as to give standards for attainment under the best conditions of forest ownership and management.

The more recent yield tables, such as Sterrett's for loblolly pine, have given figures for height not of the average trees at different ages, but of the dominant trees. This is on the basis that the dominant trees are the ones which will remain in the stand, and their development in height is more truly the growth of the stand than figures for a series of average trees which do not remain average trees with increasing age. The same reasons apply with equal force to the determination of age in constructing or using yield tables in approximately even-aged stands. The present custom is to base the ages of stands on the age of the average tree or trees. As Professor Graves expresses it on page 250, "A stand having a range in age of even 20 years forms a fairly even crown canopy when it reaches middle age—that is, 40 to 60 years—and is classed as an approximately even-aged stand. Such stands are used in constructing normal and empirical yield tables and their average age exactly determined."

Stands of this character are common in New England white pine, but normally the younger trees in them are continually being overtopped.

This process of the elimination of the younger trees tends to increase the age of the average tree faster than the calendar advances.* A stand on the Harvard forest had the age of its average tree increased from 38 to 41 years by a light thinning, which removed only trees that would surely have died in 15 years or less. In predicting yields the question of age is, "What will be the age of this stand after a certain number of years has elapsed?" If the age of the average tree at present plus the period that is to pass will not do, the present age of one or, better, the average age of several of the trees certain to remain in the stand does give a starting point, and those trees are the ones now dominant.

To sum up, this investigation has shown that for stands of white pine in New England there can be found a minimum number of fairly evenly distributed trees per acre for any age which corresponds to full crown cover and consequently maximum yield for the age and site. This gives a standard by which young stands may be judged for stocking prior to the closing of the crown canopy, and breaks down, for this species at least, and possibly for most conifers, the idea that the normal yield table in its customary form traces the only conditions of the development of maximum yields. It is also evident that in dealing with approximately even-aged stands for predicting growth with yield tables or in yield-table construction the age as well as the heights of the dominant trees rather than of the average trees should be used to classify the stands.

If these views are accepted, the data given in the present form of normal yield table are insufficient for actual field work in predicting growth in pure coniferous stands and a new form is submitted as more applicable. The figures given are merely illustrative, since as yet there are not enough data available to justify any claim to reliability for most of the entries. In using such a table the first step would be to subdivide the whole area on the basis of variations in stocking as is necessary under present practice, or possibly with less care, in that all portions of the area showing more than a certain minimum degree of stocking could be classed together. Then comes the counting on selected plots of known areas of the trees likely to survive to the final age for which the prediction is wanted, and this need not be done where it is evident that complete crown canopy will certainly be reached. Such counts offer no insuperable difficulties to one familiar with stands of all ages. The present average age of several dominant trees of at least average development for their class should be determined, and as a guide to quality of site their heights measured. The measurements of the heights of all the largest trees until those forming a third of the basal area of the dominants have been taken involves too much time for field use, although doubtless an excellent standard in yield-table construction. If the stand is already of an age for which complete figures are available, the determination of its present volume would make possible the close location of the quality of site by interpolation between the figures for the qualities given in the table. Otherwise no more field data are needed.

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* This change in age has been pointed out by European foresters (*e. g.*, Lorey), but the writer does not know of any clear discussion of it with reference to American conditions, and under our rudimentary silvicultural practice its effect is marked in many cases.

Suggested form for yield table. Pure white pine. Quality II

Average age of dominants.	Average height of dominants.	Number of trees.	Average yield, board feet.
10	5		
15	15		
20	25		
25	33		
30	41		
35	48	150	10,000
		200	13,000
		250	15,000
		300	17,000
		350 or more	18,000
40	54	150	18,000
		200	20,000
		250	22,000
		300	23,000
		350 or more	24,000
45	60	150	23,000
		200	26,000
		250	28,000
		300 or more	30,000
50	66	150	31,000
		200	35,000
		250	37,000
		300 or more	38,000
55	71	150	35,000
		200	39,000
		250 or more	42,000
60	76	150	40,000
		200 or more	47,000

THE MEASUREMENT OF INCREMENT ON ALL-AGED STANDS

BY HERMAN H. CHAPMAN

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The commonly accepted method of determining the increment of all-aged stands of timber is a study of the current growth of the trees by diameter classes. From the past average growth in diameter breast high of trees of each diameter, the current volume growth of the stand is computed for a past decade or two and predicted for a similar future period. The method has the merit of dealing with stands in their actual present condition, and the results can be applied with reasonable facility to large areas on the basis of a stand table obtained in reconnaissance.

The drawbacks of this method lie in its failure to indicate the changes taking place in all stands by reason of diminishing numbers and its inability to indicate the actual productiveness of an acre of forest land, which can only be shown by ascertaining the mean annual growth over a rotation.

A forest of all-aged stands may be compared to one composed of stands of even age with each age class represented. In the former case each age class instead of being segregated is dispersed throughout the entire area. An even-aged stand occupies approximately the same area at maturity as it does at its inception. The surviving trees constantly demand more space, and this is attained by the suppression of the weaker individuals. Should the analogy hold good for all-aged stands, we must assume that the area actually utilized by each of the age classes in such a forest also remains constant.

But this generalization is entirely unwarranted. The struggle for increasing amounts of light and moisture, which in the even-aged stand is fought out among trees of equal age, becomes in the all-aged forest a contest between different age classes on the same area. In such a contest the older trees which remain vigorous have every advantage in both crown spread and root penetration, while the immature trees and reproduction exist only in the blanks or because of tolerance. Two age classes cannot completely and effectively occupy the same area at the same time. From this relation two important results appear which affect yields. First, there is an inevitable expansion not merely of the growing space required by each surviving tree, but of the area occupied by an age class as a whole. Secondly, the age of the trees subject to competition with older timber is greatly prolonged and does not represent their economic capacity for production of timber.

Were it possible to analyze an all-aged forest into its component age classes and correctly assign to each the actual area it now occupies, the resulting yields per acre based on age will greatly underestimate the productiveness of the forest as measured by mean annual growth. This may be illustrated by a theoretical case. Suppose that in all-aged forest of a comparatively intolerant species as yellow pine the average yield per acre from a single age class is 25,000 board feet at 100 years. The mean annual growth is 250 board feet on the supposition that this crop has utilized the entire acre for the whole period; but in the all-aged stand this is not true. The original seedlings occupied very little space, and only by slow expansion following the removal of older trees has this age class come to occupy an acre. Were it possible to have measured this space from time to time throughout the rotation, the average space occupied might be nearer .75 acres, which would raise the actual mean annual growth per acre to 333 board feet. This simply means that on at least one-fourth of the area an additional amount of timber has been harvested within the 100-year period, besides that represented by the age class finally cut. This result would occur in all forests of selection or all-aged form, even in each age class were comparatively free from suppression, for on the removal of mature single trees the half-grown timber is bound to expand and appropriate part of the released space to the exclusion of seedlings.

Added to this factor of expansion is that of suppression. Reproduction of tolerant, and under some circumstances of intolerant species, occurs under the crowns of older timber, shut off from light and competing for moisture with the mature trees. Growth under such condition is astonishingly slow, both in height and diameter. The suppressed age classes make a small annual gain, but are utilizing but a minute fraction of the resources of the area. It cannot be said with any truth that this period of suppression is necessary or should be included in determining the mean annual yield of an acre of land. The true economic age of such trees is that which they require to reach a similar size when growing free from overhead competition and contesting only with trees of their own age. The inclusion of the full age of such trees gives an error exactly similar to that incurred by not allowing for expansion. For instance, a spruce stand yields at 200 years a cut of 25,000 feet per acre, giving a mean annual growth of 125 board feet, and it is found that these trees undergo an average period of suppression of 65 years. In 15 years even-aged groups of open-grown spruce reach the same size. On this basis the economic age of the stand is 150 years rather than 200 years and the mean annual growth is 166 feet.

To sum up these points, an analysis of an all-aged forest into age classes and areas would still result in an underestimate of yields per acre through failure to account for expansion of areas and for suppression, both of which factors are equivalent to double occupancy of areas or more than one crop during the rotation. Even if it were possible to determine the number of square feet or acres which are occupied exclusively by but one age class, we are sure that this age class has not needed this entire space through the rotation, and that more timber per acre is yielded than the final results indicate.

The factor of expansion of areas as an age class gets older lessens the mortality in all aged forests in comparison to the struggle in even-aged stands; fewer trees get a start, and of these a larger per cent survive to maturity. Increased growth on the trees remaining after removal of old timber is due primarily to this expansion of available growing space and occurs in virgin forests of selection form in a lesser degree from the same causes.

Studies of yields per acre in even-aged, unthinned stands will remain the most reliable basis of increment determination. The measurement of current increased growth on plots which have been thinned will most nearly indicate the results after logging; but it is evident that this increase should be gauged on the basis of area as well as of the volume of the trees. Theoretically, the fewer of these left per acre, the more rapid the growth on each tree and the greater the growth per cent on volume; but the growth in board feet per acre will depend as well upon the resulting density of stocking.

It has appeared desirable to attempt to obtain yields per acre based on age for those species and types which do not usually grow in even-aged stands. Of these yellow pine is an example. Where this species grows in groups, within which groups the age is approximately the same for all trees, it would seem that plots intended to include but one age class or group might still be used, provided the investigator can determine the correct size of the plot and include an amount of space equivalent to that really demanded by the group. The difficulty of doing this increases as the groups diminish in size.

A second method in these group forms is the one advocated by the author for use in southern yellow-pine stands, and consists in an attempt to sketch the actual areas of four principal age groups on a single plot—termed veterans, mature, young merchantable, and immature. This method gives a close approximation of the true areas when conditions are such that the entire area of the plot is stocked, and apparent blanks are in reality occupied by the extended roots of older trees. But in the drier soil conditions characteristic of western yellow pine the percentage of blank space was so great that it became at once impossible to determine by sketching the areas to be attributed to each age class, although in the more densely stocked mixed conifer type of the Sierras a fair degree of success was obtained in a trial in 1912 on the Plumas National Forest.

Attention then turned to the possibility of correlating growing space with the individual tree. In even-aged plots ring counts on two or three representative trees establish the age of the plot or class. But the determination of the age of age classes in all-aged stands is a very different problem. Inspection does not reveal the age of a class, nor can the felling of a tree or two be of much help in determining it. Each tree may be of a different age. The only possible solution is the correlation of average age with diameter and the application of this average age to the stand on the basis of its diameter classes.

The method of determining the age of trees of given diameters is familiar to foresters, consisting of measuring decades from pith to bark, or, if preferred, counting first from bark to pith. But the application to determine age of standing timber involves the securing of a correct average rate of growth for the trees concerned. Here is where the error due to including at its full value the period of suppression must be eliminated by studying open-grown trees if necessary.

When the age of a group is sought, which includes a range of diameters and has been separated by ocular inspection and sketching of the area, the average age of the group, determined from an average curve of diameter or age, should correspond with the average diameter found by volume or basal area. But since this method of separation of age groups cannot be applied to spruce or similar tolerant trees, the only other recourse is to assume that each diameter class represents a separate age class.

Under this assumption the age of each diameter class might be considered as determined from the average curve of diameter based on age. But this introduces an error. It is well known that even in all-aged stands the loss in numbers is continuous throughout the development of an age class, and that the trees which die are almost invariably the slower-growing individuals, while those specimens which grow the fastest will reach the largest size in a given period and will be among the survivors. The curve of average diameter for trees at each successive age rises by elimination of slow-growing suppressed trees as well as by actual growth of those remaining—*i. e.,* the average growth improves by elimination of the poorest growers. For this reason it is best to include in such a curve only those trees which have already reached merchantable size.

But even this curve gives too great an age for trees of the larger diameter classes, for a classification of trees by diameter eliminates the slower-growing trees from the average much more rapidly than does a classification by age. Trees may reach the maximum age for the species and still be far below the maximum diameter, while the largest trees are found to be practically but little older than many smaller companions.

A method of more nearly approximating the true age of the trees of larger diameters used in experimental work in the South was to analyze separately the growth based on age of 20 per cent of the largest trees, plot this curve of growth above that for average trees, and then connect the two curves by a third curve which originated at the lower merchantable limit and terminated with the upper curve.

It is assumed that this intermediate curve represents the average age of all trees of a given diameter, its rise being caused by the successive elimination of trees on account of size, which enter into the lower average curve of growth based on age.

Such a curve, however, is only suggestive. In practice larger diameter classes should probably be averaged together. Diameter as an indication of average age is most reliable when it can be applied to comparatively small timber, and the trees analyzed must correspond to the average conditions in point of density of stand and quality of site.

This determination of the average age of diameter classes is usually worth while, even if the study is pursued no further, since the data obtained gives a valuable indication of the rotation age and period of maturity and the proper diameter limit of cutting. But the true problem remains of determining the actual space occupied by each diameter class, for this, with the age of the class, would give us yields per acre and mean annual growth, subject to the correction or increase discussed under expansion, the factor of suppression being eliminated by the proper age curve.

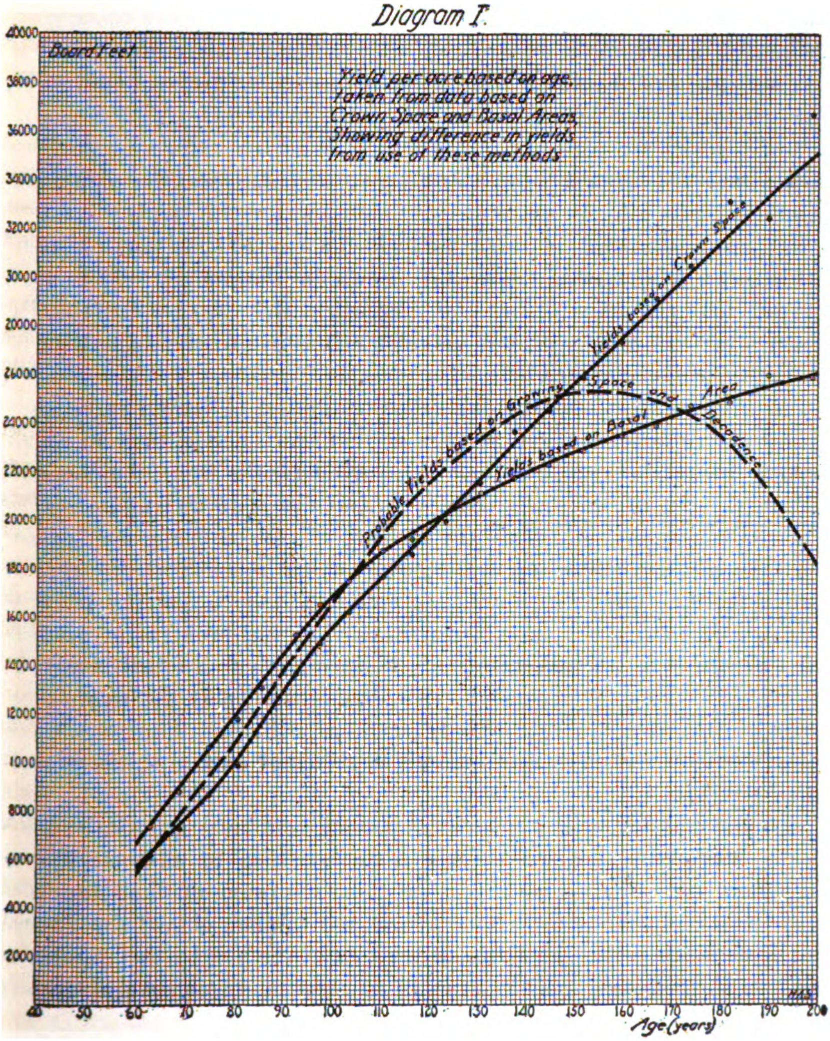
Up to date this problem has apparently not been solved in a satisfactory manner. The factor desired is the actual growing space or area required by an average tree of each diameter. This obtained, it is a simple matter to multiply this area by the number of trees in the diameter class to obtain the total area utilized and from volume get yields per acre. The application of results can be considerably broadened by determining not the actual, but the *relative,* areas needed by the different diameters, for this relation can be expressed in terms of per cents and applied to stands of varying densities. Any investigation along this line would in fact seek to determine this relation rather than an arbitrary area for trees of each class that would apply only to the plots measured and to stands of exactly similar character.

Pinned down to the tree as a unit, there are but three plans for investigating this relation between diameter and growing space, namely, basal area, crown spread, and direct approximation.

Basal area has been suggested because of its simplicity. The plan is to apportion the total area of the plots among the diameter classes (age classes) present in proportion to the basal areas of the diameter classes. This plan is fundamentally wrong, since it assumes that the basal area of an age class remains in a fixed relation to the area demanded by the tree and age class. But in fully stocked, even-aged stands this assumption is unquestionably false, as the basal area steadily increases, while the total area of the stand cannot change. The same relation must hold good for all-aged stands.

Crown space has long been regarded as a very fair indication of growing space. A method of determining yields per acre for artificial stands by means of the average crown space of dominant trees in virgin stands is described in Graves' Mensuration, page 328. A simple method of rapidly measuring the crown space of trees is to use a plumb-bob, one man sighting in the vertical projection of each side of the crown, while a second man measures this diameter in feet as projected on the ground at right angles to the observer. This diameter may then be multiplied by 3.1416 to get circular crowns, or it may be squared, since the proportion between crowns, which is all that is really desired, is obtained as well from one as the other. In practice, since the stand is treated as an all-aged forest, no distinction is made between dominant, intermediate, and suppressed trees of the same diameter, the average crown spread being sought. To get yields per acre the number of trees of each diameter on a plot is multiplied by the crown area. These totals are added, and each total is then divided by the grand total to obtain its per cent. The per cent for each diameter class is applied to the area of the plot to get the area for the class. Since age and volume of class are obtainable, the yield table is easily constructed. To obtain it, divide volume by area to get yields per acre for each diameter. Plot the resultant yields and read off the yields on the even decades.

Mechanically the method gives highly satisfactory results, as a series of points is obtained from each plot. But it is like a map constructed by a skillful draughtsman from inaccurate field data; it is unsound and unreliable. The premises, resting as they do upon the assumption that crown spread correctly indicates the required growing space, must first be proved. This is questioned on two grounds. Silviculturally it is known that tolerance decreases with age, resulting in a necessary thinning of the canopy and increase in the amount of space required in proportion to crown spread. Indicatons observed in longleaf and shortleaf pine indicate that on dry soils root spread increases faster than



crown spread. The second objection appears from the results themselves. The mean annual growth in even-aged stands culminates at a reasonable age and then declines. There is no reason to doubt that this is true also for groups or all-aged stands. Yet when crown spread is accepted as a basis for area both yields per acre and mean annual growth continue to increase to an advanced age. Both tests indicate that on this basis the area assigned to the veteran classes would be smaller than it ought to be. The effect of such an error is fundamental, since it disturbs the proportion and upsets the percentages for all classes. Too small an area for a class means too large a yield and the per cent and area for remaining classes is thereby increased, with resultant lowering of yields.

The result obtained by these methods upon a 20-acre plot of shortleaf pine in Arkansas is graphically shown in Diagram I. The dotted curve which crosses the others was obtained in this case by mapping the actual areas of age groups, and comes much closer to the facts than do either of the other curves.

It is fair to state that the objections to the use of crown space apply with greatest force to the older age or diameter classes, and on stands composed wholly of younger trees fairly good results would be obtained.

A third plan remains to be tried—that of direct approximation. The idea underlying this is that all the factors influencing the growing space of trees find their expression in the results actually obtained. Just as in even-aged stands the best results are obtained from measuring the final yields of plots of different ages, so in solving the problem of growing space for trees of different diameters it seems as though results might be obtained by direct measurement. All that is wanted is the *relation* between the total space required by trees of different diameters. The *actual* space is less important—merely a means of obtaining the proportion desired.

The method suggested is best applied in even-aged groups, and the results may then be applied on a diameter basis to all-aged forests. Plots should be laid out in groups in which the range of diameters is as restricted as possible. By means of average volume, obtain the average diameter on the plot. Then divide the area of the plot by the number of trees on it to obtain the direct relation between diameter and average growing space.

As many points as possible are obtained from stands showing different average sizes. These points can be plotted, area on diameter, and from the resultant maximum, minimum, and average curves it can be shown whether a consistent proportion exists between the diameter and growing space of trees of different diameters. Differences in site must be carefully distinguished as in all yield-table work.

The results of such studies of yield for all-aged stands are useful in two ways. The first has been discussed, namely, a better knowledge of actual productiveness of forest land and of the culmination of mean annual growth. The second purpose is to obtain the total actual increment on large areas or entire forests.

Yield tables based on age give the most reliable basis for current growth on stands of density similar to those in the table, for the changes in numbers and in rate of growth are properly accounted for, as they cannot be in actual current growth studies. But no yield table, however made, will apply to a large area of virgin forest without reduction. The problem of empirical stocking, in which the average density of the whole depends on factors which vary with each subdivision, must be solved in some sensible way, or increment for the forest remains a mere guess.

With yields based on diameter classes for all-aged stands, by the method outlined this reduction is easily made. A stand table must be obtained from reconnaissance tallies giving the number of trees of each diameter on the entire area, from which, by volume tables and average heights, the total volume of each diameter class is obtained. The area of each diameter class in the forest may be computed from the table of proportional areas according to the last method outlined, by multiplying the number of trees in each class by the proper proportion, and computing the per cent from the resulting total, which per cent is applied to the actual area in the forest. In this way actual present yields based on age are directly computed for the forest, and by the application of the principle of proportions the results are found regardless of density.

The same result may be obtained by working directly from the yield table. After finding the volume of a diameter class in the forest, divide this volume by the corresponding volume on one acre for the same diameter class in the yield table. This is done for each diameter class. The results evidently indicate the area required by the total volume in the forest, provided the stocking is of the same density as for the yield table. Should the actual area in the forest be greater or less than this result, it indicates the average difference in density of stocking from which the reduction factor is readily obtained. For instance, it is found that on a forest of 125,000 acres the total area "normally" stocked, by comparison with the yield table is 100,000 acres. The reduction per cent is $\frac{100{,}000}{125{,}000}$ or 80 per cent, and the yield table, reduced by 20 per cent, is applicable directly to the forest as a whole. In practice the application is confined to areas within the same type and quality. The principle here advocated—that of correlating a yield table with a large area of forest by means of comparison of volumes in the respective age classes with the total area involved—appears to be the simplest plan for overcoming the variations in stocking and solving the problem of the empirical yield table. It can be applied to even-aged stands, provided the area and age of each age class is determined with approximate accuracy in reconnaissance. A comparison of the density or yield per acre with the yield table will then indicate the true degree of stocking for each age class, and will enable the forester to predict with some accuracy the future yield of the age class.

There remains one important consideration in measuring increment—that of immature timber or young growth. The bearing of this age class on yields is reflected chiefly in determining total possible production for a long period and in deciding upon the degree of actual stocking present in a forest. The one consideration is complementary to the other. Yields of mature or half-grown timber will not be affected in any way by this immature age class. Therefore the average and total yields per acre for the first half or more of the rotation derived from these older classes remain the same, whether or not any account is taken of the younger age classes. But in the long run, or the latter half of the rotation, the presence or absence now of reproduction makes the difference between timber and no timber. Increment for a whole forest is apt to be computed only on the mature or semi-mature age classes—those whose diameters are large enough to measure conveniently. If yield tables have been made carefully from well-stocked plots, they usually express the yields of the age classes represented on the basis of excluding areas occupied by immature timber as belonging properly to another age class. This could be done only if such reproduction is clearly free from suppression. When such tables are applied by any method to a large area, the reduction per cent or degree of empirical stocking depends upon whether reproduction is present, and whether the areas thus reproduced are ignored or are excluded. If reproduction on an area basis is ignored and no reduction is made in total area, it is assumed that the mature timber occupies the entire tract. In the example given the reduction per cent is then 80 per cent. But in this instance, should the reconnaissance notes indicate that immature timber must be credited with 12,500 acres, or 10 per cent of the total area, the area in merchantable timber becomes 112,500 acres, which gives a reduction per cent of 90 per cent to be applied to the yield table. This change does not affect in any way the total increment predicted for the mature timber any more than the subtraction of 12,500 acres lessens the area of the forest. But it does indicate both that the degree of stocking in the forest is better than appeared in the first calculation, and that the mean annual growth per acre on mature age classes and total yield of the forest for the rotation are larger. This had its effect upon regulation of yield, and in forests well stocked with young timber shortens the period for removal of the older classes.

The rules for reconnaissance of young timber should be: eliminate tree counts which are comparatively worthless because of heavy mortality and small areas tallied, and estimate reproduction on the basis of relative abundance if very small. If suppressed no allowance should be made for area occupied; but if occupying blanks, and with good height growth, conservative estimates of the per cent of total area of forties cruised should be entered on reconnaissance sheets, from which the total area of immature timber may finally be derived. In even-aged stands such areas will be mapped, but in all-aged or group forests reproduction cannot be mapped, and its effect on density and total yields must be recognized only when it is evident that the immature age class is enjoying sufficient light and moisture to make good growth.

In the following tables an area of 1.4 acres is deducted for groups of reproduction occupying open growing space. The increase in area of crowns based on diameter for shortleaf pine is seen to be quite regular. The method of application of crown spread and of basal area to obtain the areas and resultant yields of age classes based on diameter is indicated, with the comparative results obtained. The third method of direct approximation, which would give results more nearly indicated by the dotted curve in Diagram I, was not worked out when these data were prepared. The final table, giving yields of spruce in the Adirondacks, was prepared by the crown-space method, neglecting the factor of suppression or economic age, and the results indicate, as in the case of shortleaf pine, a constantly increasing mean annual growth. The abnormally long rotation is due to suppression.

The purpose of this paper is to set forth the results obtained so far in this investigation in order to avoid a repetition of experiments which may not give the desired results, and enable investigators to reach well-founded conclusions as to the possibilities and value of studies of increment for all-aged forests.

There seems to be a tendency on the part of some investigators to assume a normal distribution of age classes in such forests as a basis of calculating increment or to strive to attain such a distribution on each acre in management. Both these ideas seem wholly artificial and unnecessary. Any practical method of studying yields or regulating the cut on all-aged forests must be based on a determination of the amount and area of the actual, abnormal age classes present, as in the case of even-aged stands:

Data from a 20-acre plot, shortleaf and loblolly pine, Warren, Arkansas, 1913

D. B. H., inches.	Trees on plot.	Volume based on d. b. h. average heights, board feet, Doyle rule.	Resulting total volumes, board feet.	Area of average crown in square feet.	Total area in crowns, square feet.	Per cent of total crown area in each diameter class.
12..........	46	67	3,082	250	11,500	2.7
13..........	49	93	4,557	295	14,455	3.4
14..........	53	130	6,890	340	18,020	4.3
15..........	43	167	7,181	385	16,555	3.9
16..........	48	220	10,560	425	20,400	4.9
17..........	59	284	16,756	470	27,730	6.6
18..........	57	339	19,323	510	29,070	6.9
19..........	62	403	24,986	555	34,410	8.2
20..........	61	467	28,487	595	36,295	8.6
21..........	40	538	21,520	640	25,600	6.2
22..........	51	615	31,365	680	34,680	8.3
23..........	42	704	29,568	725	30,450	7.3
24..........	31	794	24,614	765	23,715	5.6
25..........	22	892	19,624	810	17,820	4.3
26..........	18	990	17,820	850	15,300	3.7
27..........	14	1,095	15,330	895	12,430	3.0
28..........	21	1,207	25,347	940	19,740	4.7
29..........	6	1,322	7,932	980	5,880	1.4
30..........	9	1,438	12,942	1,025	9,225	2.1
31..........	5	1,560	7,800	1,070	5,350	1.3
32..........	2	1,685	3,370	1,110	2,220	.5
33..........	......	1,810	......	1,155	....	....
34..........	......	1,950	......	1,200	....	....
35..........	2	2,100	4,200	1,240	2,480	.6
36..........	3	2,250	6,750	1,285	3,855	.9
37..........	1	2,500	2,500	1,330	1,330	.3
38..........	......	......	......	1,370		
39..........	......	......	......	1,415	418,510	99.7
40..........	......	......	......	1,455	or 9.6 acres	

Area in immature timber, 1.4 acres.	Area occupied by each diameter class.		Resultant yields per acre for each diameter class, board feet, Doyle rule.	Age of average tree, diameter class, years.
	D. B. H., inches.	Acres.		
Net area of plot, 18.6 acres.	12	.5	6,164	63
	13	.63	7,232	69
	14	.8	8,612	75
	15	.73	9,837	81
	16	.91	11,600	86
	17	1.23	13,610	93
	18	1.29	14,900	98
	19	1.54	16,200	104
	20	1.61	17,680	111
	21	1.16	18,550	117
	22	1.55	20,230	124
	23	1.37	21,580	131
	24	1.04	23,660	138
	25	.80	24,530	145
	26	.69	25,820	152
	27	.56	27,370	160
	28	.87	29,140	167
	29	.26	30,510	174
	30	.39	33,180	182
	31	.24	32,500	190
	32	.09	37,440	198
	33	......	....	....
	34	......	....	....
	35	.11	38,180	200
	36	.17	39,700	200
	37	.06	41,660	200
	38	......	....	....
	39	......	....	....
	40	......	....	....
		18.6		

D. B. H.	Total basal area in diameter classes, square feet.	Per cent of total basal area in each diameter class, square feet.	Area occupied by each diameter class, acres.	Resultant yields per acre for each diameter class, board feet, Doyle rule.
12	35.88	2.3	.42	7,338
13	45.08	2.8	.52	8,763
14	56.71	3.5	.65	10,600
15	52.89	3.3	.61	11,772
16	67.20	4.2	.78	13,540
17	93.22	5.9	1.10	15,220
18	100.89	6.3	1.17	16,510
19	122.14	7.7	1.43	17,470
20	132.98	8.3	1.52	18,740
21	96.40	6.0	1.12	19,210
22	134.64	8.5	1.57	19,970
23	121.38	7.6	1.40	21,120
24	97.34	6.1	1.13	21,780
25	75.02	4.7	.88	22,300
26	66.42	4.2	.78	22,840
27	55.72	3.5	.65	23,580
28	89.88	5.7	1.06	23,910
29	27.54	1.7	.32	24,790
30	44.19	2.8	.52	24,890
31	26.20	1.6	.30	26,000
32	11.18	.7	.13	25,920
33	....	....	....	....
34	....	....	....	....
35	13.36	.9	.17	24,710
36	21.21	1.5	.28	24,460
37	7.47	.5	.09	27,770
38	....	....	....	....
39	....	....	....	....
40	....	....	....	....
	1,594.94	100.3	18.6	

Yields per acre based on age

Age, years.	Yield from data based on crown spread, board feet, Doyle rule.	Mean annual growth, board feet.	Yield from data based on basal areas, board feet.	Mean annual growth, board feet.
60	5,500	91.6	6,400	106.6
70	7,500	107.1	9,200	131.4
80	9,700	121.2	11,600	145.0
90	12,600	140.0	14,200	157.7
100	15,400	154.0	16,600	166.0
110	17,400	158.2	18,500	168.2
120	19,400	161.6	19,750	164.6
130	21,500	165.4	20,900	160.7
140	23,600	168.5	21,900	156.4
150	25,500	170.0	22,700	151.3
160	27,400	171.2	23,500	146.8
170	29,400	172.9	24,200	142.3
180	31,300	173.8	24,900	138.3
190	33,300	175.2	25,500	134.2
200	35,000	175.0	25,800	129.0

Relations between basal area, crown spread, and volume of single trees

[Basis, 753 trees]

D. B. H., inches.	Square feet of crown spread to one square foot of basal area.	Board feet volume to one square foot of basal area.
12	320	85
13	321	101
14	318	121
15	313	136
16	303	157
17	297	179
18	282	191
19	282	205
20	273	214
21	265	223
22	258	233
23	251	243
24	244	253
25	237	261
26	230	268
27	224	278
28	219	284
29	213	288
30	208	292
31	204	297
32	198	301
33	194	304
34	190	309
35	185	314
36	181	318
37	177	....
38	174	....
39	170	....
40	166	....

Yields of spruce, Adirondacks, 1913, based on age, not corrected for suppression, and crown space not modified

Age, years.	Yield per acre, board feet.	Mean annual growth, board feet.
50	1,000	20
75	2,900	38
100	5,100	51
125	8,000	64
150	11,400	76
175	15,100	86
200	24,600	123
225	37,000	164
250	48,000	192
275	55,100	200
300	60,100	200
325	63,400	195

DETERMINATION OF STOCKING IN UNEVEN-AGED STANDS

BY W. W. ASHE

Delivered before the Society January 14, 1914

The crown space required by a tree of a given diameter is practically constant for a species while growing on a definite quality site or within a distinct forest type. By crown space is meant the area of the air space required for the growth of the tree, and not the mere area within the periphery of the crown. This relation of the crown space to the diameter of the tree may vary, and generally does vary, with the diameter. Since most species endure more crowding when they are young, the area of the crown space required for growth increases at a higher rate than the diameter of the stem. Likewise the poorer (dryer) the quality site the larger is the crown space required for a tree of a given diameter. The relation of crown space to diameter also varies with different species, being, in fact, an indication of their relative tolerance.

While in the case of any designated species the relation of crown space to a given stem diameter is undoubtedly affected by the form of the stand (even-aged or many-aged), as well as by whether the stand is pure or mixed, this effect is believed to be immaterial. Consequently, the relation of the crown space to the diameter of the trees obtained by measurements of trees in even-aged groups (approximately of the same diameters) is applicable to trees in uneven-aged stands, and the proportion of crown space occupied by any diameter class (age class) shows its proportion of stocking in a stand.

The following method of determining the proportion of stocking would seem to be applicable for use in connection with any species which occasionally forms pure even-aged groups. It has been used in obtaining the relation of stem diameter to the diameter of crown space, which was used as a means for determining the proportion of stocking and for predicting the yield of yellow poplar in mixed many-aged stands in the Appalachians.[1]

(*a*) Select even-aged groups of different-aged classes on the same quality site or in the same forest type. The trees which enter the crown cover in these groups should have a narrow range of breast-height diameters.

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[1] Yellow Poplar in Tennessee. State Geological Survey, Nashville, Tennessee, 1913, page 38 and following.

(*b*) Determine in these groups the average breast-height diameter of all trees which enter into the upper part of the crown cover. These trees would be chiefly dominant, but there would be a few codominant ones among them.

(*c*) Determine the average area of the crown space occupied by each of these trees by dividing the total number of selected trees into the total area of ground occupied by the group.

(*d*) Plot the crown spaces in square feet thus obtained as coördinates on the average diameters of such trees in each group as form the crown cover. Even the irregularities in the areas of the crown spaces by curving. The reading of the curve of the crown spaces as the areas of circles can be reduced to diameters if desired, although they are in reality the areas of irregular polygons. The areas of the crown spaces in per cent of an acre consequently show the proportion of stocking for a tree of a given breast-height diameter.

(*e*) Since the breast-height diameters of the trees, from the manner in which they are obtained, are based on quality site and age, and consequently are correlated to the volume and increment tables which have been made for this quality site or forest type, the crown spaces or their diameters are also so correlated.

In the case of any species which forms pure groups this procedure is simple, and a table of crown spaces is easily derived from sample plots taken for the determination of yield. Once that this relation of the area of crown space to the breast-height diameter is determined for a species on a given quality site, it is always applicable to the same species under like conditions of growth. This method is applicable to species which, on account of root competition for soil moisture, occur in open stand or which form groups separated by open spaces.

In putting this method into practice it would be essential, in cases where several quality sites occur on a tract, to prepare a type map showing the quality sites at the same time that the field examination was made. It would be necessary to determine the quality sites of the sample areas on which measurements were made by plotting the diameters of the trees on their total heights, or, if age is determined, height on age would be a better guide. The average crown space of the selected trees can then be plotted on the average breast-height diameters of the same trees for each quality site.

Where the trees occur in groups separated by open spaces the area of each group (sample areas) should be regarded as extending to approximately half the distance between that group and adjoining groups. Intervening groups of seedlings and of small saplings which make a limited demand on soil moisture should be neglected. Of course, the influence of groups of thrifty old trees would extend further from their centers than from groups of younger trees which occupied equal areas, but it should not be difficult approximately to determine the line of tension between such adjacent groups.

A group of veterans on the decline may show that they require less crown space than the somewhat smaller trees which are more thrifty—that is, there may be quite a number of large saplings, or even small poles, which are coming up near them, indicating that the veterans, in spite of a larger diameter, are making less demands on soil moisture than younger and more vigorous trees of smaller size.

Where the trees in the even-aged groups are somewhat scattered there might be more difficulty in defining the line of tension between the group. Figure 1 shows how even-aged groups separated by wide open spaces might be segregated into sample areas for securing measurements. Figure 2 shows how a portion of an open stand might be so segregated.

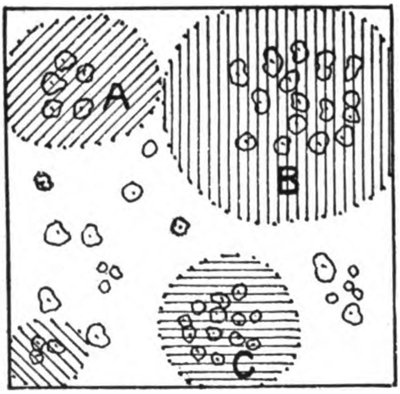

FIG. 1

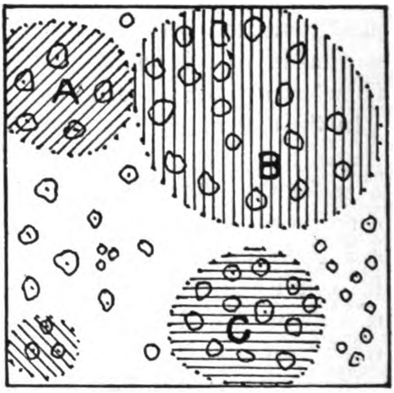

FIG. 2

FIG. 1.—A, B, C, compact groups of trees growing on dry soil which are suitable for the determination of the area of crown space required for growth

FIG. 2.—A, B, C, open groups on dry soils which are suitable for the determination of the area of crown space required for growth

The dotted lines around the shaded areas indicate in the case of each group the tension zone

YIELD-TABLE METHOD FOR ARIZONA AND NEW MEXICO

BY THEODORE S. WOOLSEY, JR.

Contributed

The main problem to decide is, first, whether a more accurate yield table for western yellow pine in Arizona and New Mexico is required, and, second, if such a table would be useful in a consideration of Land's policy and in the determination of rotations and other forest management problems what yield-table methods is advisable. The first question, practically speaking, can be answered in the negative today, but in a few years fairly accurate yield tables will be almost a necessity. The second problem will be discussed at length.

H. H. Chapman, in a series of articles that appeared in Forestry Quarterly (Vol. VII, pp. 385, ff) and in the Proceedings of the Society of American Foresters (Vol. IV, No. 2), proposed a new method of determining the yield in an uneven-aged stand. In an article that appeared in Vol. X, No. 3, of Forestry Quarterly, entitled "A Method of Investigating Yields per Acre in Many-aged Stands," he states (p. 468): "This method as described is recommended for western yellow pine."

The essential principle of the method is to divide the stand into four broad-age classes and to determine the increment and yield per acre per annum of each as though it were an even-aged stand. Each type and site quality requires separate determination.

It is presumed the object of these yield tables is to secure as accurate as possible a prediction of the growth per acre of western yellow pine under normal conditions. By normal, in this instance, is meant the production in fully stocked stands as now found in Arizona and New Mexico on different qualities of soil. Small natural openings are undoubtedly normal for the species in question, but, on the other hand, larger openings or parks would, of course, be excluded. To obtain growth figures to represent an average over larger areas would be of little value from either the technical or practical standpoint, as these can now be obtained from reconnaissance estimates. It should be borne in mind, moreover, there are now about 1,400 acres which have been measured and mapped as permanent sample plots where the growth per cent under practical conditions of timber sales can be closely approximated. These plots will within 20 years or less furnish valuable growth per cent data.

Any new method of determining the yield must stand the test of simplicity, ease of application, sufficient accuracy, and above all must serve a real need. Chapman's method in its original form does not meet any of these requirements. This conclusion is based upon the application of this method to the western yellow pine of the Southwest, where it has been tried out.

To begin with, the fundamental feature of Chapman's method—the law upon which the whole theory is built—is defective. The assumption that the larger the tree the larger the crown space does not hold true in veteran stands. Over-mature trees have as a rule small and straggling crowns, and their roots cover each year a progressively decreasing area, until finally they are no longer able to support the tree, which topples over. One must not be confused by the presence in the ground of long, thick roots of old yellow pines. These roots are not a criterion of the actual area that such trees utilize. They are the remnants of the root system of the previous stages.

Even if such a law existed its expression could not be detected in the board-foot measure which Chapman uses in his new tables. Whatever may be the relation between the diameter of the tree and its growing space this is certain, that the board measure does not increase proportionately with the increase in diameter. The growing space of each diameter class is not proportionate to the growth in board measure, as the Scribner Decimal C board-foot rule does not increase regularly with increase in diameter. If such a law existed it could only be detected by expressing the yield in cubic contents, which would be the only true unit upon which to base calculations. These facts are of such elementary nature that it is unpardonable for any one to overlook them. It must be admitted, moreover, that the roots of the various classes of trees interlace, and consequently even if we had an exact knowledge of the behavior of root systems from youth to old age it would help us but little in our determination of yield, as it is an impossibility to separate the area covered by the roots of one tree from that covered by the roots of another. In other words, any relationship between feet per acre and the area covered by root systems of the different age classes is indefinite and uncertain. That the yield does not follow the growing stage is convincingly proved by Recknagel in his try-out of Chapman's method on the Coconino Forest.

Recknagel,[1] in attempting to follow Chapman's instructions, apportioned the blanks according to the relative crown space of each age class, but found this to be fallacious: (1) because such apportionment assumes that the blanks belong to the various age classes according to the proportion of total crown cover each age class represents, and (2) because it assumes that they are blanks and nothing more.

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[1] Office Manuscript Report by A. B. Recknagel on "A Try-out of Chapman's Method of Studying Yields." Prepared in 1913.

> "While it is true," says Recknagel, "that blanks are the universal condition in present-day yellow-pine stands, they are not normal in the long run, at least not to the extent of being nearly 60 per cent of the area, yet our present-day yield tables to be of service must take them into account. But the assumption that what is true on 40 per cent of the area already stocked is true of the remaining 60 per cent of the area seems less warranted than the assumption that 60 per cent of the present-day blanks are potential forest, though without cover today, and hence belong equally to each of the four recognized age classes."

For this reason he divided the blanks equally between the four age classes and got more reasonable results than by the other method, which is in itself a death blow to the Chapman method.

The extensive crown mapping, which until recently has been the other fundamental feature of the method, is of no advantage and positively has its drawbacks. Probably the cost of crown mapping is so great that at least double and probably three times the area could be covered if ordinary sample-plot measurements were used and without a corresponding accuracy to justify this undue expense.

In order to obtain an accurate check on the mapping already done under Mr. Recknagel's supervision, with a view of determining how much variation must be expected between two maps for the same ground cover and to determine how much "generosity" was allowed in mapping, Mr. Scherer, of the Fort Valley Experiment Station, remapped an average area of two acres without any reference whatever to the previous map. This difference is considerable. The solid crown cover areas where there are groups of trees in reality showed only from three-fourths to one-third the areas mapped by Mr. Recknagel by allowing "generosity and judgment." This is especially apparent in the group of yellow pine in square No. 19. It is not so noticeable in the case of black jack in square No. 18, but still very apparent and of sufficient divergence to change the results very materially.

Mr. Scherer reported:

> "A typical area was selected without any previous reference to the map. It includes all crown classes. The planimetered areas follow:

Class	As on Recknagel's map.	As remapped, trees singly.
Veteran	0.085	0.075
Mature	0.427	0.288
Black jack	0.241	0.161
Reproduction	0.108	0.010
Blank	4.139	4.466
Total acres	5.000	5.000

While this method is supposed to be based on a definite law, in the field it actually amounts to the personal judgment of the field men and a great deal of guesswork, or, as Chapman would put it, "generosity in mapping" the crown areas of veterans in order to eliminate the discrepancy between the yield of the veterans and the growing area that can be allotted to them. All the advocates of Chapman's method who have tried it out unanimously agree that the mapping is subject to error, and Moore, in his 100-page dissertation on Chapman's method, concludes that it is almost impossible to secure men who are experienced enough to apply the method. As a matter of fact, men familiar enough with the timber to apply the method do not need such a complicated procedure, and I hope to be able to show that there is no reason why they cannot use the regular yield-table methods known to the foresters for many decades.

Chapman's method, as a rule, recognized four age classes—veterans, mature trees, young (in the case of yellow pine called black jack), and reproduction. It appears that the establishment of the age-class "reproduction" is misleading, as reproduction comes in in all-aged forest, as a rule, under the shelter of veterans. Under these conditions it would be necessary to map two crown covers under the same growing space. This is obviously impossible.

The reproduction is troublesome in still another way, since it is likely to play havoc with the yield estimates. Suppose the estimate was made at the time when the blanks were not covered with natural reproduction. In five or ten years after the stand has been measured reproduction may appear in the blanks or under another age class. That would mean altogether a new redistribution of blanks among the different age classes and the whole plat would have to be recomputed, and thus the entire answer of the yield problem would be changed, whereas the volume itself of the stand as distributed among different age classes would not be materially different.

There is still another even more fundamental objection to the so-called Chapman method. To be of any value a yield table must show quality classes based not upon guesswork, but upon actual measurements taken in the field. It is true that with the Chapman method a variation could be shown which would correspond roughly to quality classes; but would this be as accurate as if the limits of the quality classes were based upon the extreme and minimum points denoting the minimum and maximum height of a moderate number of sample plots? With the large area covered by the Chapman plots it is quite conceivable that more than one quality of soil would be included. If the plots were made small in area the method would be impracticable, because an essential detail of the method is to include more than one—usually all—age classes. With ordinary yield-table methods, when the areas covered are from 1 to 5 acres more or less in extent, a large number of plots may be collected without undue expense, and consequently quality classes may be more readily differentiated.

The use of diameters for determining the age of different groups in an all or uneven aged stand is a pretty dangerous procedure. In the western yellow pine, for instance, the age does not vary as much as might be expected by a divergence in size.

An interesting example of the danger of relying on the average diameter to determine age is found in C. S. Chapman and A. W. Cooper's study of the Weyerhauser tract. Here plots were measured which showed varying average diameters. The investigators hoped to make a yield table by getting the age of each plot from the diameter age. When they worked it out it was found that the plots were all about the same age, and that the greater the diameter the fewer the trees; practically but one point for a yield table was secured. The final results were obtained by plotting this one point in the Pinchot white-pine yield table secured in the Adirondacks and by drawing a similar curve. This is a good example of the danger of getting diameters without corresponding ages on each particular plot. The age of the average trees in each age class should be determined for each particular plot.

The yield table secured by Chapman's method are empirical yield tables in the sense that they seek to give the yield of the present stand; but to accomplish this he resorts to a highly theoretical and supposedly normal growing space occupied by trees of different ages. In order to get his empirical yield table, he practically constructs his normal yield table on the basis of the growing space required by trees of different age classes, and then reduces that normal yield table by the proportionate area in each age class—a rather involved method for determining empirical yield.

Of course, there is a grain of truth in Chapman's method; but in so far as it is correct it is not Chapman's, namely, that in order to construct a yield table for uneven-aged stands it is essential to determine the area actually occupied by each age class, as the increment varies in each age group, and only the sum total of the increment in different age groups will give the true increment for the entire stand. The method, however, which Chapman suggested for arriving at the areas occupied by the different age groups is too involved to be of any practical value. Chapman's method is a very good idea not clearly crystallized, even in the mind of its creator. This method must undergo a great many modifications, possibly so many that the author would not recognize his creation, before it can be seriously considered as a practical solution of determining the yield of uneven-aged stands.

If, however, it is not practical to use the method suggested by Professor Chapman in western yellow pine, what methods are practical, economical, and easy to put into effect? In order to answer this question, Mr. Scherer, of the Fort Valley Experiment Station, was requested to choose, map, and caliper within the 20-acre (Chapman method) plot selected by Professor Recknagel two areas, one in a compact, apparently normal stand of black jack, the other in a similar apparently normal stand of western yellow pine. As an additional check two plots were chosen in black jack and in yellow pine near the 20-acre plot, thus making four plots in all.

In laying out these plots the boundary was not run immediately under the crowns of the outside trees, but half way between the plot to be measured and surrounding timber. In other words, there was no costly crown mapping, but a reasonable amount of open space so characteristic of yellow-pine stands in the Southwest was included in the plot. This boundary was not drawn in the office by guesswork through allotting a proportionate amount of space to each class, but was allotted in the field after a careful consideration of the local conditions. For instance, if two stands were separated by an open space 70 feet wide the boundary would run 35 feet from the boles of each stand. Where this boundary touched on a larger opening, which, according to a knowledge of local stands, appeared to be abnormal and due to some external cause, the line would not be run to the middle of the park, say two or three hundred feet from the plot being measured, but in the example cited perhaps 35 feet from the exterior boles. In actual practice, however, it would undoubtedly be possible to secure stands for measurement of fairly even age, which would not present any unusual boundary problems. Tables 1 to 6 show the results secured from the four plots.

TABLE 1.—*Total number of trees on basis of diameter breast high*

Diameter breast high, inches.	Plot 1, black jack, 1.95 acres.	Plot 2, black jack, 2.135 acres.	Plot 3, yellow pine, 1.035 acres.	Plot 4, yellow pine, 2.9 acres.
3 Classed as unmerchantable.....	1	......	......	......
4	1	1	......	......
5	2	2	......	......
6	3	2	......	......
7	5	2	......	1
8	11	......	......	......
9	10	2	......	5
10	6	5	......	3
11	10	7	1	6
12	15	6	3	4
13	12	12	1	2
14	10	14	2	5
15	17	6	1	10
16	7	12	1	6
17	8	14	3	6
18	8	5	3	8
19	6	8	2	6
20	6	6	3	10
21	3	4	5	15
22	3	3	6	8
23	1	5	7	5
24	1	1	5	7
25	......	......	3	7
26	......	1	3	4
27	......	......	2	1
28	......	......	......	2
29	......	......	2	4
30	......	......	......	3
31	......	......	......	1
32	......	......	2	......

TABLE 2.—*Plot No. 1. Black jack outside of the 20-acre plot previously measured*

	Trees from 8″ to 14″, d. b. h.	Trees from 15″ to 24″, d. b. h.	Average.
Diameter class	8–14	15–24	....
Age (years)	121	124	122
Sample tree, d. b. h	11.25	17.7	....
Mean average tree, d. b. h	11.3	17.7	....
Total height	52	67.7	....
Merchantable length	19.6	43	....
Corrected scale	43	183	....
Number of trees in class	74	60	....
Total feet, b. m	3,182	10,980	7,237 ft., b. m., per acre

Corrected area = 1.957 acres.

Table 3.—*Plot No. 2. Black jack within the 20-acre plot previously measured*

	Trees from 8" to 14" d. b. h.	Trees from 15" to 26" d. b. h.	Average.
Diameter class	8–14	15–26	....
Age (years)	123	120	122
Sample tree, d. b. h.	18.8	12.6	....
Mean average tree, d. b. h.	18.5	12.6	....
Total height	67	53	....
Merchantable length	51	31	....
Corrected scale	245	76	....
Number of trees in class	65	46	....
Total feet, b. m.	15,925	3,496	9,096 ft., b. m., per acre

Corrected area = 2.135 acres.

Table 4.—*Plot No. 3. Mature western yellow pine within the 20-acre plot previously measured*

	Trees from 11" to 16" d. b. h.	Trees from 17" to 22" d. b. h.	Trees from 23" to 32" d. b. h.	Average.
Diameter class	11–16	17–22	23–32	....
Age (years)	258	225	205	236
Sample tree, d. b. h.	24.2	21.5	12.7	....
Mean average tree, d. b. h.	25.5	20	13.3	....
Height	96	93	55	....
Merchantable length	85	78	33	....
Corrected scale	920	479	88	....
Number of trees in class	24	22	9	....
Total feet, b. m.	22,080	10,538	792	*32,280 ft., b. m., per acre

Corrected area = 1.035 acres.
* Probably an abnormally high figure.

Table 5.—*Plot No. 4. Mature western yellow pine outside of the 20-acre plot previously measured*

	Trees from 9" to 16" d. b. h.	Trees from 17" to 23" d. b. h.	Trees from 24" to 31" d. b. h.	Average.
Diameter class	9–16	17–23	24–31	....
Age (years)	329	224	212	244
Sample tree, d. b. h.	26.7	20.2	12.5	....
Mean average tree, d. b. h.	26.8	20.2	13.2	....
Total height	94	94.3	60.5	....
Merchantable length	74	66	27	....
Corrected scale	940	420	74	....
Number of trees in class	29	58	41	....
Total feet, b. m.	27,260	24,360	3,034	18,846 ft., b. m., per acre

Corrected area = 2.9 acres.

TABLE 6.—*Summary of the four plots*

Average age.	Plot No.	Total feet, b. m., per acre.
122	1	7,237
122	2	9,096
236	3	32,280
244	4	18,846

One allowance or correction factor was made in all these plots. For example, if in the black-jack plot there was a mature western yellow pine the actual growing space occupied by this tree was deducted from the area of the plot. The amount of this deduction was arrived at by placing the boundary between this tree and the surrounding stand half way between the tree bole and the surrounding stand. This is subject to some error; but it is certainly more correct than if the tree was included, and the error caused by the deduction of a few trees would be so small as not to affect the final result to an appreciable extent.

Table 6 gives the average age, the plot number, and the total feet, board measure, per acre for the four plots. The figures in the black-jack plots 1 and 2 are reconcilable and seem to me to clearly indicate the entire feasibility of regular yield-table methods in western yellow pine. Plot No. 3 appears to be abnormal, and probably in the case of a complete yield study would either be entirely discredited or else retained to form the maximum curve of yield. Whether it is abnormal or not could not be determined until 100 or more plots were computed. Plot No. 4 seems normal and, since it covered between two and three acres, should probably be accorded more importance than plot No. 3. Since one of the chief justifications for the Chapman method was that it was the only method by which yield tables could be secured in uneven-aged stands, such as western yellow pine, the fact that sufficiently even-aged stands can be secured obviates the use of the method, aside from its technical inconsistencies and extravagant cost due to mapping the crown cover.

A reference to Tables 2, 3, 4, and 5 shows that the age of western yellow-pine trees does not vary as much as might be expected by their divergence in size. For example, four black-jack sample trees had an extreme range of only four years, namely, one 121, one 122, one 123, and one 124. There was some divergence, to be sure, in the mature yellow-pine class, but probably this divergence would not be so great in all cases. Here the extreme variation was 124 years, namely, 205, 212, 224, 225, 258, and 329; but when it is considered that the yield-table plots would if possible be located in stands having a maximum age of 160 to 220 years, this divergence of age in the mature class is not of such vital importance.

Another solution of this problem, somewhat different from the one just described, suggested itself in the process of work. This, however, will be discussed at some other time.

YIELD IN UNEVEN-AGED STANDS

BY BARRINGTON MOORE

Contributed

The purpose of this paper is to crystallize the problem of yield in uneven-aged stands by an analysis of the fundamental difficulties encountered and to further its solution by definite suggestions. Details of methods can readily be found in the literature of the subject, and will not be given.

The problem in hand is the determination of yield in uneven-aged stands, not the regulation of the cut. The latter is done under the French method of 1883, the single tree or Brandis method, volume methods, and others which do not directly concern the question of studying the yield.

The problem in the United States as compared with the problem in Europe should be clearly understood and kept in mind. The crucial point is that in the United States we must measure past yields and predict future yields in *virgin forests,* whereas Europeans are concerned only with yields in second-growth forests, a much simpler matter. The necessity for knowing the growth of virgin forests is twofold: First, the answer to the pressing question as to whether we should cut immediately to save loss through death and decay or whether we can afford to wait depends largely on the present increment; if the increment is very low or a minus quantity, it is advisable to cut as soon as possible, whereas, if the increment is still satisfactory, we can wait. This applies, of course, only to the Federal and State governments and to owners in a strong financial position, the only ones interested in forest management. Hence, other considerations being equal, the cutting policy depends directly upon the increment. Second, the bulk of the stands in the United States which are under management are virgin. Therefore, in calculating the allowable cut, it is essential to know the yield of virgin stands; to say that "in virgin stands growth is offset by decay" no longer solves the problem. We have learned that the growth of virgin stands is by no means stationary. The increment over large areas may be higher now than it will be for some years after cutting; in other cases the increment is fairly high now, but gradually diminishing, and will become a minus quantity in 50 or 60 years; in still other cases, though these are exceptional, the present net increment may be a minus quantity.

It is this necessity for yield data on virgin as well as on second growth stands that makes the problem in this country so difficult.

European literature is of assistance with regard to certain fundamental principles, but not with regard to detailed methods. In Europe there is comparatively little overmature timber, and the question of mortality per cent, one of our worst stumbling-blocks, does not exist in stands cut at frequent intervals, and in which suppressed trees are utilized for thinnings. Furthermore, European management is so intensive that they can afford to make repeated studies of yield covering only short periods. The common method is that of applying the current growth of individual trees to stand tables. Even with their relatively simple conditions they do not attempt to predict yields for more than 10 or at most 20 years ahead, and then claim little for the accuracy of their results.

The problem will, for the sake of clearness, be treated under two main heads: 1, Existing Methods, under which will be given the salient points of strength and weakness in methods already tested in the United States; and 2, Suggested Methods, under which will be given new methods or modifications of already existing methods.

EXISTING METHODS

Current Growth of Individual Trees

The first study of the increment of uneven-aged stands in this country was made by Austin Cary in Maine, and is described by him in the Report of the Forest Commissioner of Maine for 1896, pp. 26-27; 122-128, and Appendix, p. 21 and following.

This study was made only on cut-over lands, and followed essentially the European current growth method referred to above. Cary used Pressler's method of securing the growth per cent in diameter at compound interest. In actual application he used both per cent of growth and growth in diameter. He gives a table (p. 123) showing for each diameter from 7 to 13 inches; volume in cubic feet (present), and growth in the last ten years, first in diameter four feet from the ground, second in per cent compound interest, and third in cubic feet per annum. To use these data in finding increment per acre he determines the number of trees of each diameter class now standing and their present volume, and applies his growth figures to each diameter class to find the volume after 20 years (p. 128). The results are worked up in both cubic feet and board measure. Finally he gives the increment per acre in cubic feet, board feet, and the percentages of each which can be expected after cutting to diameter limits of 14 inches and 10 inches, respectively, and clearly shows that the lower limit greatly reduces the producing power of the land.

The next study of increment in uneven-aged stands was made by Graves in the Adirondacks. He followed essentially the method employed by Cary, except that he did not use Pressler's method of per cents, and got his growth in diameter by complete counts, instead of by counts of only the last decade.

The underlying trouble with the method as applied to virgin stands is that it fails to take into account loss of numbers through suppression, windfall, or other agencies. Loss of numbers is of great importance in almost any stand, but especially so in virgin stands and stands not under intensive management. In even-aged stands this loss or mortality can readily be measured; in uneven-aged stands no satisfactory method of determining it has yet been found. Graves, in his Mensuration (p. 336), says that "this is usually a matter of judgment and observation, rather than of actual measurement." In India, where increment is found by practically the same method of current growth of individual trees applied to stand tables (only the standard of measure is number of trees of certain diameters rather than volume), the mortality is frankly guessed at. Another, though less serious, difficulty is that it fails to account for the increased growth of individual trees after cutting. For these reasons the method has been but very little used in this country.

Nevertheless, for cut-over stands this method, predicting yields for only short periods ahead, is as simple and satisfactory a method as any that has yet been devised.

Professor Chapman's Method

The second method of importance is that devised by Prof. H. H. Chapman, of Yale, for determining the yield of longleaf pine in the South. It is adapted only to the study of uneven-aged stands in which each age class forms a distinct group. Briefly, the principle of the method rests upon the determination of the age, volume, and area of each age class separately. For this purpose each age class is actually mapped and its area planimetered; the age is found by stump counts, and the volume by actual measurement.

The method is described in the Proceedings of the Society of American Foresters, Vol. IV, No. 2, p. 207, and in the Forestry Quarterly, Vol. X, p. 458. There is also in the files of the Forest Service a manuscript giving the details of the method, step by step, as it was applied on the Plumas National Forest.

The advantages of the method are that it secures the three bases necessary in any study of yield, namely, area, age, and volume; that it automatically takes care of the vexing question of mortality per cent, and that, by taking plots of 10 to 40 acres in size, it obviates the inaccuracies inevitable with small plots where a large proportion of the trees are on the edges with their crowns extending outside of the plot. It contains automatic checks in that errors in mapping one age class will affect the other age classes, and will show up through failure to correspond with the law of diminishing numbers. Lastly, it shows what the forest is actually producing, regardless of theoretical normality, and gives figures which, by a simple process, can be applied in determining the increment of any area covered by a system of reconnaissance which furnishes a stand table, as does the ordinary strip system.

But the method has a number of disadvantages. First. Since it assumes that diameter is a function of age, the growth figures must be taken on the same site quality on which the plots are to be measured. This is generally difficult on account of the limited area of cuttings suitable for growth studies. Second. Its actual application in the field is complex and rather cumbersome, particularly where there are more than one species in the stand. A number of the details, points of minor importance, yet points which may materially change the results, give trouble. It involves an enormous amount of arithmetical computation, and only by constant checking and rechecking can errors in computations be avoided. It can be successfully used only by men with thorough technical training, full experience in the timber in question, sound judgment, and a good share of common sense.

The main problem, however, is the determination of the area occupied by each age class, and the most difficult point in this problem is the veteran or overmature age class. Errors in one age class will affect the others. Hence, if, as is always the case, the area of the veterans is mapped too small, the yield of this age class will be too large. We know from studies in even-aged stands and from the laws of tree growth that increment per acre per annum (not the increment of individual trees) becomes stationary at a certain period in the life of the stand, and then falls off. If, in mapping, the veterans are given only the space which their crowns occupy, the resulting yields are too high, and frequently the number of trees per acre will figure out as high as the class below, an obvious impossibility. Chapman believes that this trouble is due to the fact that veterans have a greater root spread than crown spread, and suggests studies to determine the relation between the root area and crown area of veterans. Such a study was planned by Notestein on the

Montezuma National Forest, but was not carried out. The only other alternative is to use judgment in mapping the veterans and to be extremely generous in the area allotted to them. This sometimes works fairly well if the investigator exercises care and has good judgment. It is, however, a distinct objection to the method. Furthermore, Zon differs from Chapman in his idea of the relative area occupied by thrifty large trees and by veterans. Zon claims that veterans, having passed their prime, gradually lessen their demands both on light and on soil moisture. Their crowns become more and more ragged and visibly smaller than those of the thrifty large trees. Zon feels confident that the same holds true for their roots, and that veterans, therefore, occupy less growing space than thrifty large trees. Actually it matters but little whether the growing space occupied by the veterans is greater or less than that occupied by the thrifty large trees; the controlling point is not the growing space *now* occupied by the veteran age class, *but the area occupied by that class during its entire life.* Take, for example, the history of a group of trees. During the seedling and sapling stage the group is surrounded by older trees. As the stand grows older and the surrounding trees gradually die, the crowns of the group in question occupy the space thus given, and also spread into blanks. Thus the area of the group is increased. Up to maturity the number of trees in the group constantly diminishes because of competition for light and moisture, but, except for the increase above noted, the area of the group remains approximately constant. At maturity the ground is fully occupied (except for blanks which existed when the group started), and each tree has full growing space. Then the important change commences. From now on the loss in numbers is not due to competition, but to entirely different agencies, such as mechanical injuries, insect attacks, windfall, and old age. Each loss—and this is the keynote of the situation—results in an opening which henceforth is no longer filled by the increasing crowns of other members of the age class. Thus the group in its veteran stage contains many openings, sometimes filled with reproduction and sometimes blank, which were originally occupied. Therefore *the actual growing space occupied by veterans does not represent the area which the group covered in its younger stages.* For an accurate yield table the area which the group covered in its younger stages, not the growing space of the present trees, must be allotted to the group. In even-aged stands the plots take this into account automatically; they will contain large blanks in the veteran age classes. In uneven-aged stands occurring in groups the question is most difficult, sometimes impossible, to solve. Occasionally the area originally occupied by the group may be told by windfalls, dead trees, decaying logs, etc.; but even then there is considerable uncertainty, for some of the trees may have disappeared entirely, and their places may be occupied by young growth.

Evidently, then, for small groups the total area originally occupied by the veteran age class can never be measured with strict accuracy except by permanent sample plots carried over a long period of years, though it may sometimes, by the use of good judgment, be mapped with sufficient closeness for all practical purposes. But in stands which form large groups covering two acres or more it may be possible to secure this area by laying off small plots within these groups just as if the stand were even aged.

Hence, as far as the veteran age class is concerned, there seem to be only three alternatives in the use of Chapman's method:

(1) For stands in which the age classes form large groups: Map the veterans according to growing space, as under the present form of the method. Then lay off a number of plots, not less than half an acre in size, preferably two acres, in large groups of veterans, and treat these plots as if they were even-aged stands. In laying out these plots care must be exercised to place them in stands representative of the age class—that is, stands having the natural amount of blanks caused by the death of individuals through old age, windfall, or other injuries. Take the number of trees per acre from these plots, and apply it to the large plots which have been previously mapped. This will give the area which the veterans should occupy—that is, the area which the class covered in its younger stages. This area should be considerably greater than that found by the original mapping of growing space alone. Take this increased area from the area mapped as blank. Then distribute the remaining blank area among all the age classes according to the area of each, and compute the yields as under the regular method. If desired, the yield of the veteran class may also be worked up from the small plots as a check.

(2) For stands in which the age classes form only small groups: Map with the veterans as much of the area which they originally occupied as can be determined from old logs, stumps, etc. When such indications cannot be found, use your knowledge of the form in which the groups generally grow. This is unsatisfactory in that it bases the result too much on guesswork; but if the investigator possesses a thorough knowledge of his timber and good judgment, the figures will still be of considerable value.

(3) The third alternative is to beg the veteran question completely and confine the method to cut-over areas, preferably after Forest Service

sales, where cutting has been under the group-selection system. The yield table will, of course, be less satisfactory in that it will apply only to cut-over stands.

The yield of the veterans, as mentioned before, has been the chief objection to the method. If this difficulty is overcome by the foregoing suggestions, or otherwise, I feel that the method will be of very great value in determining the yield of uneven-aged stands in which the age classes occur in groups. Even so, the method will still require ingenuity to meet the minor difficulties which arise from time to time under different conditions, and can never be used mechanically by men with little experience and poor judgment. These objections need not, however, overbalance the many other advantages of the method.

SUGGESTED METHODS

Three methods have been suggested: the first, involving the use of small plots, has been tried, but the results not yet made known; the second, based on density, is being tried in connection with cutting experiments on permanent sample plots in the Rockies, and the results will not be known for a number of years; the third method, based on crown area, has never been carried out in the manner suggested, although the principles have already been applied with considerable success.

Small Plots

The small-plot method, suggested by Woolsey for use in the yellow pine of Arizona and New Mexico, is simply the method used in even-aged stands, applied to uneven-aged group stands by selecting groups large enough to include small even-aged plots.

The advantages of this method are its simplicity and its avoidance of all the difficulties and problems involved in other methods. These advantages strongly recommend the method for stands with groups large enough to permit its use.

The disadvantages are: (1) Small plots are less accurate than large plots because a much larger proportion of the trees are on the edges, with their crowns extending outside of the plot; (2) each plot gives only one point on the yield curve instead of a series of points as under Chapman's method. This objection is equally true of plots in even-aged stands, and is a miner point compared with the simplicity of the method; (3) the method can be applied only in stands in which the age classes occur in groups of two acres and more in size. In western yellow pine such groups are common on the Coconino National Forest in Arizona, but are rare on the Gila National Forest in New Mexico, where growth is different and where a yield table constructed on the Coconino would be wholly inapplicable. Thus the method is not sufficiently elastic to cover all conditions even in a single type.

Density Method

A wholly original method, based on the principle that yield depends directly upon density, has been devised by C. G. Bates for studying the yield of Engelmann spruce in the Rocky Mountains.

A stand is cut over under the selection system, and the yield during the past 30 years is determined. The density of the stand is ascertained by light measurements taken before and after cutting. Then it is assumed that the original density which the stand had before cutting will be attained in 20 years after cutting. The future yield is then calculated by the following proportion: *Future yield is to original yield as future average density is to original density.* The future average density is, of course, the mean between the density immediately after cutting and the density when the stand has resumed its original density. This may be expressed proportionally and reduced algebraically to the following formula:

$$YF = \frac{YO \times (DO + 46)}{2\ DO}$$

Where: YF = future yield
YO = original yield
DF = future density
DO = original density

The idea is that the increment of the stand will gradually increase as the crowns of the individuals increase and gain more light and growing power, until finally the crowns have closed and the original density is attained.

The fact that the method assumes a direct ratio between increment and density is an objection because no such ratio has ever been measured; and even though a ratio did exist, its action under different degrees of density is unknown.

These objections are, however, realized by the author of the method, who makes no claim to exactness. The method is, he states, "merely the quantitative statement of a hypothesis to be proved by later measurements." As such it is interesting and worthy of attention.

Crown-area Method[1]

The crown-area method, in the form here suggested, has not yet been thoroughly tried out in the field, but is given as a distinct possibility. It is, in reality, nothing more than a way to determine yield by the use of stand tables secured while estimating timber. The method rests upon the relation between the diameter of the tree at breast height (4½ feet above the ground) and the area occupied by the crown of the tree. This relation is, of course, not constant for all diameters, but is reasonably constant for any given diameter. Mattoon proved this for shortleaf pine for ages up to 70 years, and Chapman carried the conclusions to mature shortleaf and loblolly in mixture. Chapman also found it to exist for chestnut, and Ashe for tulip poplar. Other species have not yet been tested, but there is no reason to believe that the same will not hold true.

The principle of the method is briefly this: The crown area is determined for each diameter, and translated into growing space, thus giving the area factor the difficult question in uneven-aged stands; age is found by growth studies and volume from the estimators' tally sheets and height data. Thus we have the three bases—area, age, and volume—necessary for constructing a yield table. Stand tables worked up from the tally sheets take the place of plots.

Since the suggested form of method has not hitherto been fully described, the detailed steps are herewith given:

A crew of two men can probably work to best advantage:

1. Measure the diameter breast high and crown width, tallying in parallel columns. The diameter breast high should be secured with calipers or a diameter tape, the crown width with a 10-foot pole, using care on slopes to see that the measurements are horizontal. Wherever the crown is not perfectly symmetrical, the average of two diameters should be taken. Crown measurements may be made in one of two ways: (*a*) One man stands off from the tree, where he can see both sides of the crown; he then lines in the second man under one edge of the crown, has him measure across under the crown at right angles to his (the first man's) line of sight, then stops him under the far side of the crown. The measurer calls out the distance, and the first man records it opposite the proper diameter, which has already been measured and recorded. (*b*) Each man works alone, lining himself in under one side, measuring across under the crown, and then lining himself in under the other side. This is, I believe, less accurate than the first method, unless the men have

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[1] This method will probably be recognized as essentially the same as one Professor Chapman has recently devised. It was, however, worked up entirely independently before Chapman's new method had been made public.

previously practiced lining each other in as under (*a*), but is more rapid, especially where two diameters are required for most trees.

About 20 trees of each diameter class should be taken, representing all crown classes, suppressed as well as dominant; and if, as is preferable, the study is being made by types and site classes, the above number should be taken in each type and site quality. Two men working together should be able to secure from 300 to 400 trees per day.

In dry regions, such as the western yellow-pine region of Arizona and New Mexico, moisture rather than light seems to be the factor controlling density, and it is probable, therefore, that root spread, rather than crown spread, determines growing space. In such regions the area of the root spread should be used instead of the crown spread. To do this it will be necessary to ascertain a correction factor for each diameter class representing the amount by which the crown area should be increased to get the area occupied by roots. Such a factor can be determined accurately only by a detailed study of soil moisture such as that proposed by Notestein for the Montezuma; but it may sometimes be found roughly by careful observations of reproduction, noting the distance from the tree at which fully vigorous reproduction commences. If this factor cannot be measured, the resulting yield table will give too high values; but this will be largely taken care of in the application of the table to actual watersheds.

2. Compute the above data as follows:

(*a*) Obtain crown area by squaring the diameter of the crown.

This will give more than the true crown area, which should, of course, be the radius squared, multiplied by 3.1416. The purpose is to allow for the interstices between the crowns, since in no stand do the crowns touch on all sides, forming a perfect canopy. Hence, if the actual crown area alone were found by using the circumference, the growing area allotted on the basis of the crown measurements would be too small even for fully stocked stands.

(*b*) Plot crown area over diameter breast high on cross-section paper, placing diameter breast high along the horizontal scale and crown area (crown diameter squared) along the vertical scale.

Balance the points vertically and horizontally and draw the curve.

We now have figures showing approximately the growing space occupied by each diameter class. Although these figures may not be accurate as regards *actual growing space,* they should serve as a reasonably reliable index of *relative growing space* of trees below the veteran stage.

3. Get the average growth in diameter on age from about 100 stump counts of each species on each type and site quality. This is done in the

usual way, plotting a curve of diameter inside bark at the stump on age and converting to diameter outside bark at breast height. In order to get the *average age of trees of each diameter*, not the average diameter of trees of each age, the points for the curve should be balanced horizontally instead of vertically, at least for the larger trees.

4. Construct stand tables, each representing the average forty on each type, and, if possible, each site quality. For this use the estimators' tally sheets for the watershed in question.

Treat each stand table separately and work up the final results for each independently.

5. Consider each diameter class—that is, each inch or group of inches—as a separate age class, and make the following computations for each:

(*a*) Volume.—Compute from volume tables, using the height curves secured by reconnaissance. If groups of diameters are being used as age classes, find the volume of the average tree, and determine the diameter of a tree with this volume and the proper height according to the height curve.

Volume in cubic feet rather than in board feet should be used whenever possible.

(*b*) Age.—Find the average age of the age class by looking up in the growth table constructed under step 3 the age for the tree of the average diameter found above under (*a*)

(*c*) Area.—Calculate the area occupied by each age class by simply multiplying the number of trees in the age class by the crown area of the proper diameters read from the curve of crown area on diameter breast high constructed under 2 (*b*).

If the age class is composed of a number of diameters, do this separately for each diameter and take the totals as the area of the age class.

6. Convert the volume of each age class as determined under 5 (*a*) to a per-acre basis by dividing by the area found under 5 (*c*).

We now have all the data necessary for constructing a yield table, which will be the next step.

7. Construct a yield table by plotting for each age class volume per acre, as found under step 6; on average age, as found under step 5.

Each stand table will give a series of points on the curve, as many points as there are age classes, and will, therefore, correspond to a plot under Chapman's method. Enough stand tables should be worked up to give a sufficient number of points for each age class to serve as a reliable basis for drawing the curve.

This table will represent only fully stocked stands. It may be high for intolerant species, where each crown must have extra space; and it may be low for tolerant species, where the trees grow under each other and require less space than has been allotted them. Both of these difficulties can probably be overcome, the former by adding a measured factor to each crown diameter to allow for the extra space required, the latter by subtracting a portion of the crown area of each diameter class, taking a larger proportionate area from the small than from the large trees, or by ignoring overshadowed trees altogether in measuring crowns.[3]

The great difficulty lies, as always, in the veteran age class. Even with the above corrections, the veterans still have only the growing space which they now occupy, not, as they should have, the growing space which they occupied in their younger stages. Their yield will therefore be too high, and the curve will continue upward instead of falling off when overmaturity is reached. Here the trouble is the same as under Chapman's method and the alternatives are those already described.

Assuming that the yield of the veterans has been determined by one of the suggested alternatives with sufficient accuracy for all practical purposes, the next step is to apply the yields to the watershed in question. The table gives the yields of fully stocked stands, and we want actual yields for the area, including blanks. The process is simple.

First, the area of young growth—that is, of everything below the lowest size included in the stand table—must be ascertained. This should have been secured while the estimate was made, and should not include areas of reproduction under the merchantable stand and in the openings which properly belong to the veteran age class. If it has not been secured at the same time as the estimate, it must be obtained by mapping a number of representative plots. In this case the mapping need consider only the reproduction.

The area of the age classes of merchantable size and over has already been determined, and can be added to the area of the young growth to get the total area covered by forest on the average 40. This will generally be less than 40 acres, the difference representing blanks. The next step is to find the relation which the blanks bear to the 40, and to reduce the yields accordingly. For example, 10 acres are blank; this is $\frac{10}{40}$ or 25 per cent of the area; therefore the yield of each age class should be reduced 25 per cent. This assumes that each age class has the same relative degree of stocking, a reasonable assumption for large areas.

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[3] The objection to the last scheme is that, in estimating, the overshadowed trees are tallied with the rest.

If, on the other hand, the stand is made up of very tolerant trees, and is more or less two-storied, the area may be more than 40 acres. Theoretically, the yields should be increased proportionally just as they were reduced for the blanks. This should, however, be done with caution, because many of the trees under the older trees will be destroyed in logging.

In order to apply the yields thus determined, we must know the approximate area of each age class within each type. This is found for each type by determining the per cent of area which each age class covers in the sample 40, and applying this per cent to the total area of the type on the watershed.

The last step is simply to multiply the reduced yields by the area of each age class in each type.

The results should be a fairly reliable index of the production of the watershed.

THE DETERMINATION OF SITE QUALITIES FOR EVEN-AGED STANDS BY MEANS OF A SITE FACTOR

BY E. J. HANZLIK

Contributed

In the course of constructing Douglas-fir yield tables for three site qualities for the western Cascades of Washington and Oregon, the question of the determination of the qualities came up for discussion.

There are in general use three methods by which this done, being as follows:

1. Method of optical inspection, in which only a superficial examination is made of the conditions of the stand, making note of the forest, physical and climatic conditions.
2. Method of the height growth of the dominant trees; also making note of the forest, physical and climatic conditions.
3. The use of the cubic volume method, in which the stand is calipered, a cubic foot volume table is prepared, a diameter-height curve drawn, and the average cubic volume per unit area is secured, which is then compared to normal figures already prepared. In a region where nothing has been previously done, as in the Douglas-fir region, a large number of stands are measured and the cubic volume figured for each as a unit, these are plotted on cross-section paper, using the ages as the abscissæ and the volumes as ordinates, and maximum and minimum curves are drawn. The space between these two curves is divided into as many divisions as there are qualities desired, and curves are drawn which throw the various points into their proper qualities. It is by this method that the tracts (used later in this discussion) for the Douglas-fir yield tables were separated into site qualities. In this paper a comparison of this method and the formula method will be presented.

The formula method (the use of a site factor), in which the relation between the height, basal area, and age are used, was first suggested by the use of the relative height (the ratio of the height to the diameter of a tree), the basal area, and the cubic contents by the Russian forester Medwiedew.[1]

The use of the formula method is based upon the assumption that for similar site qualities, irrespective of age, a constant factor is secured. This is shown to be quite true, as will be seen later in this discussion. The formula as used for determining the site factors for the three site qualities is as follows: $F = \frac{h \times c}{n}$, where $h =$ the height in feet of the average tree in the stand, $c =$ the basal area in square feet per acre, and $n =$ the average age of the trees in the stand. This formula can be used only in determining the site qualities for even-aged stands.

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[1] Forestry Quarterly, Vol. IX, p. 497. Review from Lesnoj Journal, 1910, Allgemeine Forst u. Jagdzeitung, April, 1911, pp. 135-136.

Assuming that the bole of a tree is a cone, its volume is equal to $\frac{h \times c}{3}$ where $h =$ total height in feet and $c =$ the basal area in square feet. The volume, therefore, varies for trees of different heights and cross-sectional areas. Stands on similar site qualities of different ages cannot be compared directly by means of these two factors, since the volumes are widely different. Therefore, in order that a simple comparison may be made for even-aged stands of unequal age, it is necessary for a third factor to be introduced into the formula, which will result in a number which is tolerably constant for each quality. This third factor was found to be the age of the stand investigated, the formula in its final form reading $F = \frac{h \times c}{n}$.

In its final form the trees were assumed to be cylindrical in form, thereby doing away with the unnecessary operation of taking one-third of the height, multiplied by the cross-sectional area, making the resulting factor three times as large as it would be if the trees were treated as cones. This does not affect the division into the different qualities at all, provided the formula is always used the same.

The practical workings of the formula are as follows, taking two cases for illustration:

1. *Method of Working a Region into Different Site Classes*

In this case we may assume, for illustration, the Douglas-fir region of the western Cascades of Washington and Oregon, for which it was desired to secure yield tables for three site qualities. This species is found only in even-aged stands, to which this method is applicable.

Representative stands in various parts of the region are measured and described, each unit of description being called a tract. By a tract is meant an area over which the forest, physical, and climatic conditions are similar, involving no sharp and definite differences. For each tract the site factor "F" is worked out from the height of the average tree, the average basal area in square feet per acre, and the average age of the stand. The height (h) is secured from a diameter-height curve for the tract, the height corresponding to the diameter of the average tree being called "h." After securing a large number of tract measurements in various soil qualities, and having figured F for each tract, the division into the different sites is accomplished in the following manner:

All tracts which appear to be abnormally stocked, either over or under, should be discarded. The general range of numbers is secured, and if three site qualities are desired, a division into three parts is made. For example, for the Douglas-fir stands measured in the western Cascades, F varied from about 200 to 500, and it was desired to make a table for three site qualities. The poorer the site, the lower will be the factor secured by the formula. Therefore in this case the third quality (poorest) numbers were taken as from 200 to 300, the medium quality from 300 to 400, and the first quality from 400 to 500. It may be noted here that exceptional stands on the best site had factors considerably above 500, these stands being far above the others on the same quality of equal age. These tracts were considered abnormal, and were disregarded in making the division into the three site classes.

2. *Establishing the Quality of Site of a Tract in a Region for which Site Divisions have Already Been Made*

In this case we will again take, for example, the Douglas-fir region of the Pacific Northwest. We will assume that site classification tables have already been made, and that it is desired to establish the quality of site of a certain tract. The tract is calipered by means of sample acre plots, taken here and there, and the necessary heights, diameters, and ages taken. Then the site factor F is obtained from the formula: $F = \frac{h \times c}{n}$. This factor is then compared with the site classification table. For the region in discussion the range for each site is 200-300, 300-400, 400-500 for the third, second, and first qualities, respectively. If F falls between 200 and 300, the site is of third quality; if between 300 and 400, it is of second quality; if over 400, it is of the best quality. In this manner the work of placing the tract in its correct quality is much simpler than where it is necessary to secure the cubic volume per acre of the tract, and then decide the quality of site according to age and volume, this necessitating a table giving the volume according to age for each site class.

A Comparison of Results by the Cubic Volume and the Formula Methods

In order to determine the accuracy of the formula method a large number of tracts measured in the Douglas-fir region of the Northwest were divided into three site qualities by the cubic volume and the formula methods. The cubic volume method was used first and the qualities in the following tables were based upon the results secured by it. Tables 1, 2, and 3 give the site factors secured by the formula method; Table 1 for tracts that are regarded as Quality I sites by the cubic volume method; Table 2 for those as Quality II, and Table 3 for those as Quality III sites.

TABLE 1.—*Quality I sites. Factor limits above 400*

Tract No.	Age in years (n).	$F = \frac{h \times c}{n}$	Elevation, feet.	Locality.
1	27	*235	300	Newaukum, Wash.
2	27	†372	450	Fortson, Wash., Wash. Nat. For.
3	38	410	1,300	Saddle Mt., Siuslaw Nat. For.
4	39	463	200	Glenada, Oregon.
5	40	†347	400	Hartford, Wash.
6	49	460	1,200	Proctor Camp, Siuslaw Nat. For.
7	49	‡550	500	Deadwood Cr., Siuslaw Nat. For.
8	50	418	1,600	Hunchback Mt., Oregon Nat. For.
9	51	420	600	Cougar Cr., Siuslaw Nat. For.
10	56	450	1,800	Hunchback Mt., Oregon Nat. For.
11	57	475	1,100	Morton, Wash.
12	57	‡530	1,500	Green Mt., Cowlitz Co., Wash.
13	58	418	400	Irving, Wash.
14	59	416	400	Granite Falls, Wash.
15	62	442	700	Bacon Creek, Wash. Nat. For.
16	65	460	500	Deming, Wash.
17	70	‡525	1,600	Hyland Butte, Lowell, Oregon.
18	74	447	1,000	Cottage Grove, Oregon.
19	85	470	600	Hobart, Wash.
20	107	507	3,000	Permelia Trail, Santiam Nat. For.
21	121	518	900	Lucia, Wash.
22	125	‡623	1,200	Marmot, Oregon.
23	137	432	1,000	Lexington, Wash.

NOTE.—The tracts as listed in Tables 1, 2, and 3 were placed in their respective qualities by the cubic-volume method.

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* Should go into Quality III by the formula.
† Should go into Quality II by the formula.
‡ Abnormal stands giving an exceptional yield.

TABLE 2.—*Quality II sites. Factor limits, 300 to 400*

Tract No.	Age in years (n).	$F = \frac{h \times c}{n}$	Elevation, feet.	Locality.
24	24	*209	500	Crawford, Wash.
25	36	*225	600	Bacon Creek, Wash. Nat. For.
26	41	367	1,500	Marmot, Oregon.
27	50	346	1,100	Randle, Wash.
28	55	341	900	Saginaw, Oregon.
29	57	338	1,800	Humphrey, Wash.
30	57	†415	1,300	Humphrey, Wash. (slope).
31	57	†405	1,200	Humphrey, Wash. (bottom).
32	57	354	3,000	Huckleberry Mt., Oregon Nat. For.
33	58	373	2,000	Huckleberry Mt., Oregon Nat. For.
34	64	369	1,200	No. Fork Sauk Riv., Snoqualmie N. F.
35	67	371	3,000	Huckleberry Mt., Columbia Nat. For.
36	98	336	3,000	Minto Trail, Santiam Nat. For.
37	102	306	900	Darrington, Wash.
38	119	339	2,000	11½-mile Race-track Trail, Col. N. F.
39	126	337	300	Toledo, Wash.

TABLE 3.—*Quality III sites. Factor limit below 300*

Tract No.	Age in years (n)	$F = \frac{h \times c}{n}$	Elevation, feet.	Locality.
40	51	‡304	900	Cottage Grove, Oregon.
41	54	201	1,800	Humphrey, Wash. (south exposure).
42	57	254	1,800	Humphrey, Wash.
43	58	237	1,200	Morton, Wash.
44	59	‡303	500	Van Zandt, Wash.
45	70	294	1,500	8½-mile Race-track Trail, Col. N. F.
46	71	208	1,500	9½-mile Race-track Trail, Col. N. F.
47	80	230	2,500	Minto Trail, Santiam Nat. For.
48	97	278	3,000	Huckleberry Mt., Columbia Nat. For.
49	97	‡331	600	Hobart, Wash.
50	100	260	1,800	10½-mile Race-track Trail, Col. N. F.
51	117	‡347	1,000	Yacolt, Wash.
52	120	216	1,100	Frank Brice Creek, Umpqua Nat. For.
53	132	229	2,000	Thomas Trail, Santiam Nat. For.

Except in a few instances, it may be seen that the formula method and the cubic volume method check very well. The exceptions for the Quality I sites are Tracts 1, 2, and 5, for which the factor falls below 400, very much so for Tract 1. This low factor is rather difficult to explain: however, it may be that, due to a small number of tracts for this age, with only a limited range of differences in cubic volume, the maximum and minimum curves were drawn so as not to include a sufficient range. This is somewhat borne out in Table 2 also, where Tracts 24 and 25 are relegated to the poorest quality by the formula method. Tracts 2 and 5 were rated as Quality I by their cubic volume, although it was undoubtedly due to their excessive degree of stocking rather than to the general growth of the trees. Tracts 30 and 31 in Table 2 show factors that would place them in Quality I by the formula method. These tracts are just about on the border line by the cubic volume method, leaning toward the second quality.

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* Should go into Quality III by the formula.
† Should go into Quality I by the formula.
‡ Should go into Quality II by the formula.

In Table 3, Tracts 49 and 51 are seen to have factors considerably above the limiting number for the poorest quality, and it is thought that these two tracts should be listed as Quality II. Based upon their cubic volume, they seem right to go in the third quality, but, upon considering all factors, indications are that they were incorrectly listed as Quality III.

On the whole, it may be seen that the formula method of determining site qualities for Douglas-fir stands in western Washington and Oregon checks well with the cubic volume method. Whether it will work equally well with other species and localities is a matter for trial; the probability is, however, that the method will work as well as in the Douglas-fir stands.

DAMAGE BY LIGHT SURFACE FIRES IN WESTERN YELLOW-PINE FORESTS

WALLOWA AND WHITMAN NATIONAL FORESTS

BY THORNTON T. MUNGER

Contributed

To determine the effect which light surface fires have upon commercial timber, a field study was recently made by the Forest Service in Oregon of typical yellow-pine stands in which surface fires had occurred, probably for centuries, at irregular but rather frequent intervals. The study was simple and rather rough in its methods, and does not exhaust the subject, but the observations were made with care, so that the results can be taken, so far as they go, as very representative of actual conditions over a large area.

The first part of this study had as its object to find out how many trees are killed and fire-scarred by an average "light" surface fire in western yellow-pine forests in eastern Oregon. The second part of this study aimed to find out how many yellow-pine butt logs, cut in logging operations in this region, are actually damaged by these light fires.

1. *Number of Trees Killed and Scarred by Surface Fires*

To get this information, there were selected several typical western yellow-pine stands in the Blue Mountains of eastern Oregon, which had recently been burned over by the surface fires, and which had been periodically run over by similar fires. Strips, one chain wide, were then run in all directions across these fresh burns and all the trees tallied by species in four classes:

(*a*) "Burned to death," trees that were killed by the heat of the surface fires about their bases. In this class were placed only trees which were known to be killed by the burning of the inflammable material about them. Trees which were killed by fire in their crowns were not included, because the strips were not run where the fire was of the nature of a crown fire.

(*b*) "Felled by fire," living trees which were burned off at the base by fire eating into basal fire scars.

(*c*) "Scarred by fire," trees which were so scarred by fire at their bases that the wood of the trunk was exposed. Under this heading were included trees which had been fire-scarred by previous fires, as well as those scarred by the recent fire, since it was impossible to determine when the scars originated.

(*d*) "O. K.," trees which at the time of examination showed no bad effects from the fire.

In three separate burns in yellow-pine timber, 130 acres were tallied in this way, and the results are, therefore, representative of average conditions in this region. They show that a surface fire bells by eating out basal fire scars, on the average from one merchantable tree to each 4 acres to as high as two or three trees per acre; and that 42 per cent of all the merchantable yellow pines show fire scars at their bases. The summary of the tally on these yellow pines is shown in the following table, and, by way of comparison, the percentage of each form of injury received by other species is also given:

TABLE 1.—*Percentage of each form of injury that trees of each diameter class receive from surface fires*

Diameter breast high.	Burned to death.	Felled by fire.	Scarred by fire.	Apparently O. K.
WESTERN YELLOW PINE.				
12–18 inches	7.68	0.83	32.22	59.27
19–24 inches	4.96	5.22	39.69	50.13
25–30 inches	2.98	3.20	50.96	42.86
31–36 inches	5.83	2.92	53.35	37.90
Over 36 inches	6.31	3.16	60.00	30.53
All sizes	3.13	1.88	42.54	49.75
DOUGLAS FIR.				
All sizes	4.38	1.39	17.88	76.35
WESTERN LARCH.				
All sizes	......	2.49	33.38	64.13
GRAND FIR.				
All sizes	13.06	......	28.35	58.59

NOTE.—The figures for Douglas fir, western larch, and grand fir are in part compiled from data additional to that from which the yellow-pine figures are taken.

This table brings out the fact, which is so often observed, that the largest yellow pines are those which are most apt to be fire-scarred, probably because they are the oldest and have been subjected to the greatest number of these periodic surface fires. Yellow pine is apparently more susceptible of fire-scarring than the other species, which is in accordance with its relatively thin bark and highly inflammable wood. Grand fir, while not susceptible of severe basal fire-scarring, is apt to be scorched to death because of its low crown.

In another small burn in a pure yellow-pine forest, where the fire had been merely a seemingly harmless ground fire, 6 out of the 297 yellow pines on the 23 acres were toppled over by being burned off at the base. Being the larger trees in the stand, they represented at least 6 per cent of the merchantable timber on the tract. Such damage by a very slight fire, which is not unusual, is, of course, possible only where the area has been repeatedly burned over so that a large percentage of the trees have scars which each succeeding fire enlarges.

Not alone are 1.8 per cent of the merchantable yellow pines gnawed off at the butt by each surface fire, and 42 per cent of the remainder scarred so that they are liable to be a prey of the next fire, but many of those which survive the fire are badly damaged for the use of the lumberman by having their butts "pitched" and by having a piece of the base actually consumed.

2. *Damage to Butt Logs as a Result of Repeated Fires*

The presence of "fat pitch" in the log depreciates its value for commercial purposes, since when much pitch is present the lumber will be as low grade at least as C Select.

In order to see just how much material was lost in a logging operation on account of fire scars, and what percentage of the butt logs were pitchy, a special record was kept of all the yellow-pine butt logs on a timber sale on the Whitman National Forest. The result of this study upon 900 butt logs shows the following interesting result:

TABLE 2.—*Damage to butt logs*

Description of logs.	Number of logs.	Per cent of total number of logs.	Average in scale per log.	Average deduction in scale per log.
			Feet.	*Feet.*
1. With small fire scars only.........	47	5	265	....
2. With small pitchy areas only......	258	29	369	....
3. With bad pitchy areas............	18	2	471	52
4. With bad fire scars and pitchy areas.	150	17	329	58
5. Defective, but not because of fire...	15	1	467	160
6. Free from defect................	412	46	229	....
Total.........................	900	100	297	[1] 27

[1] Of the defective logs only.

The average diameter of the pitchy areas on the basal cross-sections of the 276 pitchy logs is a little less than 14 inches, but no deduction in the scale of these logs was necessary except in the case of 18 of them in which the pitching was greater—up to two feet in diameter sometimes.

The record of the butt logs for 1,184 trees (kept in two tests) shows that:

22.8 per cent of the butt logs show fire scars.

18.6 per cent are so defective because of fire damage that deduction in their scale is necessary.

46.1 board feet, or 14 per cent of their volume, is the average amount lost in each defective log.

25 per cent of the logs show in their basal cross-sections areas of "fat pitch," averaging 14.7 inches in diameter.

These figures may be taken as representative of conditions in the yellow-pine forests of eastern Oregon, which have been repeatedly subjected to surface fires. Striking as they are, they underestimate rather than overestimate the actual damage to the merchantable trees, for some of the most defective butts were left in the woods in high stumps and were not taken account of in this tally.

To express this loss in dollars and cents, in general terms for all fires, is quite impossible. Each fire, no matter how light it is, does damage to the commercial timber, often not in a conspicuous way, but nevertheless in a very real way. It may be said that each surface fire in this region kills outright a merchantable tree to each two or three acres, it leaves 42 per cent of the remaining merchantable trees fire-scarred so that they may fall victims to the next high wind or surface fire, and it "pitches" the butts of a large proportion of the best trees. These facts forcibly indicate that not only are surface fires immensely detrimental to the future welfare of a yellow-pine forest, but they also seriously depreciate its present commercial value.

FIRE DAMAGE IN MATURE TIMBER

BY J. ALFRED MITCHELL

Contributed

There has always been considerable difficulty experienced by forest officers in estimating fire damage where the stand in question was not entirely killed. This has been especially true when the examination was made immediately following a fire, and has resulted in many estimates of fire damage being widely at variance with the facts.

In order to obtain some definite information, therefore, that would serve as a guide in cases of this kind, and to determine, if possible, the susceptibility to damage and the power of recovery of various species, a study of fire damage was started on the Klamath National Forest in the fall of 1910 by Forest Assistant Allen.

For the purpose of the study, a sample plot of one acre was laid out on a recent burn. The fire, a severe surface and brush fire, had occurred about six weeks previously, and, while it had not destroyed any of the trees in question, it had scorched them so severely that it was thought some might die. Each tree on the plot selected was numbered and a careful description made as to the nature and extent of the injury.

In November of the following year (1911) a re-examination of the area was made. The result of these two examinations is shown in the following table:

Tree No.	D. B. H.	Condition of trees six weeks after fire.	Condition of trees fourteen months after fire.
		YELLOW PINE	
	Inches.	(*Pinus ponderosa*)	
1	26	Has a few green leaves, but no part of crown wholly green. Probably dead.	Top vigorous; practically all limbs green, at least at tips.
2	26	Same as No. 1...............	Top 15 feet of crown fully recovered.
3	20	Upper 5 feet of crown partially green on one side. Cat face 5 feet long near base.	Upper 15 feet of crown green, at least at the tips.
4	26	Upper 5 feet of crown partially green on one side.	Practically recovered. Lowest limbs only dead; others green, at least at tips.
5	28	Upper 6 feet of crown green on one side.	About 20 feet of crown green on one side at tips only.

Tree No.	D. B. H.	Condition of trees six weeks after fire.	Condition of trees fourteen months after fire.
		YELLOW PINE—continued *(Pinus ponderosa)*	
	Inches.		
7	26	Upper 5 feet of crown green one side. Grown over fire scar one side, 5 feet up from ground.	Upper 50 feet of crown green one side; lower limbs at tips only.
8	20	Upper 8 feet of crown green.	Upper 35 feet of crown green; lower limbs killed.
9	18	Upper 6 feet of crown green on one side.	Upper 15 feet of crown green, but on one side only at the tips.
10	22	Upper 12 feet of crown green on one side. Bad cat face 20 feet from ground on one side. Butt hollow 1 by 3 feet on other.	Upper 25 feet of crown green on one side; upper 15 feet on other side. Woodpeckers at work on butt.
12	18	Upper 6 feet of crown green on one side. Sap burned through 62 feet up from base, so that tree is almost girdled.	Upper 15 feet of crown recovered; balance dead.
14	20	Upper 8 feet of crown green.	Upper 25 feet of crown green on one side.
17	30	Upper 30 feet of crown green.	Recovering. Green needles at least at tips of all but lowest limb.
18	28	Upper 8 feet of crown green.	Recovered; only lowest limb killed.
19	22	Upper 2 feet of crown green.	Upper 15 feet of crown green; lower limbs dead.
20	28	Upper 6 feet of crown green. Deep fire scar 6 feet up from base.	Top green except lowest limb.
21	24	Upper 8 feet of crown green. Deep butt scar 2 feet high.	Upper 40 feet of crown green; lowest branches only dead.
22	22	Upper 6 feet of crown green. Deep cat face near ground 6 feet long.	Recovering.
23	24	Upper 6 feet of crown green.	Upper 40 feet of crown green.
24	22	Upper 6 feet of crown green.	Practically recovered.
25	18	A suppressed tree. Upper 2 feet of crown green. Bark burned through for 6 feet up from the ground on one side.	Condition unchanged.
26	20	Upper 12 feet of crown green.	Upper 30 feet of crown green; only lower limbs killed.
27	16	A weak tree originally. Upper 5 feet of crown green.	Condition unchanged.
29	14	A very weak tree, but crown entirely green.	Condition unchanged.
30	20	Upper 8 feet of crown green.	Upper 25 feet of crown green; lower 10 feet dead.
31	24	Upper 6 feet of crown green on one side.	Upper 20 feet of crown green, but only at the tips on one side; lower 15 feet dead.

Tree No.	D. B. H.	Condition of trees six weeks after fire.	Condition of trees fourteen months after fire.
		YELLOW PINE—continued	
	Inches.	(*Pinus ponderosa*)	
32	20	Upper 5 feet of crown green.	Upper 15 feet of crown green.
33	28	Upper 20 feet of crown green. A very thrifty tree.	Recovered; only lowest limbs dead.
34	24	Upper 6 feet of crown green.	Upper 30 feet of crown green; lower 10 feet dead.
35	16	Upper 4 feet of crown partly green. Deep scar 2 feet from ground.	Upper 15 feet of crown green on one side at tips only.
36	12	Bayonet top. Upper 6 feet of crown green.	Upper 20 feet of crown green, the lower half at the tips only; lowest 10 feet of crown dead.
37	12	Upper 8 feet of crown green.	Upper 20 feet of crown green; lower 15 feet dead.
38	10	Weak tree. Upper 6 feet of crown green.	Upper 15 feet of crown green; lower 12 feet dead.
39	20	Upper 15 feet of crown green. Deep fire scar 4 feet long at base.	Crown green for 30 feet. Fully recovered.
40	18	Upper 8 feet of crown green. Bad fire scar at base.	Upper 15 feet of crown green, at least at tips.
41	22	Thin crowned. Upper 5 feet green. Deep fire scar 3 feet long at base.	Recovered. Entire crown (25 feet) green, at least at tips.
42	28	Upper 6 feet of crown green.	Crown green for 30 feet on one side and 15 feet on the other; lower limbs dead.
43	24	Upper 16 feet of crown green.	All but lowest limbs green (25 feet).
		SUGAR PINE	
		(*Pinus lambertiana*)	
15	32	Upper 8 feet of crown green.	Upper 30 feet of crown green; lower 10 feet dead.
16	36	Upper 12 feet of crown green.	Upper 30 feet of crown green, at least at tips; lower 10 feet dead.
28	32	Upper 20 feet of crown green.	Upper 25 feet of crown green; lower 1/3 dead.
		DOUGLAS FIR	
		(*Pseudotsuga taxifolia*)	
6	28	Thin crowned originally. Upper 6 feet of crown green. Deep fire scar 6 feet up from ground.	About 8 feet of top green. Apparently healthy. Balance of crown dead.
11	24	Upper 6 to 8 feet of crown green. Butt almost hollow for 6 feet.	Upper 8 feet of crown only green.
13	28	Upper 5 feet of crown green.	Upper 8 feet of crown only alive.

From the above it will be seen that the yellow pine in question had largely recovered from the effects of the fire. None had died, and in most cases only the lowest limbs had been wholly killed. No insect injuries were apparent, and the damage to butts and boles was apparently confined to the fire scars made or enlarged at the time of the fire. In almost every case the dead or brown needles had dropped off, except on limbs which had been killed outright, and only live or green needles remained. Where the crowns had been scorched most severely, only the terminal whorls of green needles were in evidence. This would indicate that the terminal buds had escaped while the old needles had all been killed.

The sugar pines had also recovered, and the damage in most cases was not serious. The injury, however, was, in general, more serious than in the case of the yellow pine, a larger percentage of the crowns having been killed and fewer terminal buds escaping.

With the Douglas fir the case was entirely different. While the tops of the three trees of this species included in the study area were still live and green, the needles on the scorched limbs had dropped off and the branches were apparently dead.

While not conclusive, this study tends to show that yellow pine is the more fire resistant of the three species noted and recovers most readily. Sugar pine is apparently a close second, while Douglas fir, on the other hand, is evidently quite subject to fire damage and has little power of recovery.

In this same connection, it is interesting to note the results of a somewhat similar study on the Shasta National Forest in the spring of 1911. The trees in this case were smaller and the fire correspondingly lighter; but the results, it will be noted, are strikingly similar.

Tree No.	D. B. H.	Ht.	Condition of trees two weeks after fire.	Condition of trees six months after fire.
			YELLOW PINE (*Pinus ponderosa*)	
	Inches.	*Feet.*		
2	4	18	Tree apparently dead. All leaves turned brown by the heat.	Upper 8 feet of crown green, terminal buds having survived.
3	5	20	Upper 18 inches of crown green.	Upper 10 feet of crown green.
4	3.5	16	Only tip of crown green. Recovery doubtful.	Upper 8 feet of crown green. Practically recovered.
5	3.5	10	Entire crown yellow. Tree probably dead.	Tree dead. Insects at work on trunk.

Tree No.	D. B. H.	Ht.	Condition of trees two weeks after fire.	Condition of trees six months after fire.
			YELLOW PINE—continued (*Pinus ponderosa*)	
	Inches.	*Feet.*		
6	3	15	Same as No. 5............	Upper 5 feet of crown green and thrifty.
7	3	14	Same as No. 5............	About half the needles in the upper 3 feet of crown are green. Leader alive. Tree unhealthy looking, but will probably recover.
8	6	20	Upper part of crown green; lower part yellow. Will probably live.	Upper 8 feet of crown green and thrifty; lower 12 feet dead. Apparently no serious injury.
12	5	15	Upper 2 feet green. Balance of crown yellow. Recovery probable.	Upper 5 feet of crown green and thrifty. Lower limbs dead.
13	6.5	28	Upper 3 feet green. Balance of crown yellow. Recovery probable.	Upper 12 feet of crown green and thrifty. Lower limbs dead.
14	10	42	Upper 4 feet of crown and lower limbs still green. Balance of crown yellow. Recovery probable.	All but lower 12 feet of crown green and thrifty.
			INCENSE CEDAR (*Libocedrus decurrens*)	
1	6	19	Upper 4 feet green. Balance of crown yellow. Recovery probable.	Upper 4 feet of crown, a few twigs on lower branches green. Conditions thrifty.
9	3	14	Crown yellow and apparently dead.	Leader dead. Two branches only are green. Condition dubious.
10	7	22	Bark scorched on one side. Crown green. Death improbable.	Lower 12 feet of crown on the uphill side and 5 feet on downhill side dead. Balance of crown thrifty.
11	6	?	Crown green except a few lower branches. (Double tree.) Death improbable.	Crown dead to a height of 8 feet on the uphill and 5 feet on the downhill side. Balance of crown thrifty.
15	4	14	Upper half of crown green; lower half yellow. A small hole burned through the bark at the base, probably an enlargement of a previous injury. Recovery probable.	Upper half of crown green and thrifty. Wound healing over.

Tree No.	D. B. H.	Ht.	Condition of trees two weeks after fire.	Condition of trees six months after fire.
			INCENSE CEDAR—continued	
	Inches.	*Feet.*	(*Libocedrus decurrens*)	
16	4.5	13	Crown entirely yellow except the tips of a few branches. Recovery doubtful.	Upper 2 feet of crown and several side branches green. Tree in poor condition, but will probably live.
17	5	14	Crown entirely yellow except the tips of a few branches. Recovery doubtful.	Uphill side of crown killed to tip. Downhill side and leader green. Condition fairly good.

The most important lesson to be learned from these studies is the danger of snap judgments in estimating fire damage. This arises from the fact that with certain species the apparent damage is out of all proportion to that actually incurred. The above, for example, indicates that yellow pine is the least subject to fire damage, sugar pine next, incense cedar next, and Douglas fir most of all. The reasons for this are not entirely clear, but the heat resistance of the terminal buds is apparently the determining factor.

It is evident, therefore, in estimating the extent of damage to the crowns of conifers by fire, that the condition of the terminal buds is the most reliable indication. With old trees this is difficult of determination, but in appraising the damage to reproduction it is more easily arrived at.

In general, it may be said of yellow pine that where any part of the crown remains green the tree will survive and the portion of the crown not actually charred will recover. With sugar pine, a tree with leaves still green, especially at the tips, will probably survive. The recovery of the balance of the crown, however, is less certain and depends on the severity of the scorching it has received.

The terminal buds of incense cedar are apparently less heat resistant, and this species is usually no better than it looks immediately following a fire. It may even be more severely damaged than at first appears. On the whole, however, it can be classed as fairly fire resistant.

Douglas fir is, on the other hand, apparently quite subject to injury and has little power of recovery. It is usually, however, no more badly damaged than first appearances indicate.

DISEASES OF THE EASTERN HEMLOCK

BY PERLEY SPAULDING

Contributed

A study of the diseases of the eastern hemlock (*Tsuga canadensis*) has been made by the writer for a number of years. He also formerly had considerable experience with the hemlock in small lumbering operations in northern New England. The hemlock is one of the few eastern species of trees which remain to some extent in the original first-growth generation. It has been quite largely left as a cull from former lumbering operations, so that at the present time there is probably a larger percentage of mature trees of this species than of any other in the average woodlot of the Eastern States. But the situation is rapidly changing because of the value of the bark for tanning purposes and the increasing value of the lumber, so that mature trees are now being felled much faster than young ones are taking their place. Because of its very slow growth, the mature hemlock is one of the oldest trees of the eastern forests, and it is doubtful if the oldest generation of hemlock will ever be replaced by mature trees except in the wildest and most inaccessible sections.[1] Notwithstanding the relative great age of mature hemlock, it is surprisingly free from serious troubles. Windshake is probably the most prevalent trouble with the species. The writer has had little opportunity to pay especial attention to the parasitic fungi on hemlock, but as above intimated has incidentally collected a considerable number of such fungi. It has seemed advisable to gather together the scattering data upon the diseases of the hemlock, and the following notes are the result of an attempt to briefly state the general facts concerning this subject. Our own data in the form of collections and observations form the basis of the following statements, and are supplemented by various published statements of other investigators, as indicated by the footnotes.

For convenience the diseases may be arranged under the three general headings: Physiological diseases, fungous diseases, and fungi attacking dead timber.

PHYSIOLOGICAL DISEASES

Windshake

It is known by practically every lumberman who as handled hemlock timber that this species is especially subject to windshake. Practically all writers who have paid any attention to the general conditions of growth of this species have mentioned it.[2] This trouble is so prevalent that lumbermen expect to lose a cut of several feet in length at the butt of many mature trees. The loss from this trouble varies much in different locations, nearly all large trees being affected in some places, while they may be practically free from it in others. It is supposed to be due to the twisting and bending action of the wind, and the sharply defined annual rings seem to favor the tearing apart of the rings, such as occurs with this trouble.

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[1] See citations on pp. 255–256.

Windthrow

Although hemlock is a shallow-rooted tree, its habit of growing in mixed stands prevents it from windthrow to a great extent.[3] Quite often trees affected with windshake or heart-rot are broken over by heavy winds. This, in the writer's experience, is more prevalent than windthrow.

Snow and Ice Breakage

Although the hemlock has a rather brittle wood, the living tree is not especially liable to breakage by heavy snow or ice storms. This is probably partly due to the manner of growth of this tree. The branches extend nearly horizontally from the trunk and thus bend downward with any considerable weight, allowing the snow to slide off before they break. It has been mentioned as breaking under heavy loads of snow in Germany;[4] this is evidently where the tree is used as an ornamental and is allowed to retain its lower branches.

Drought and Sunscorch

The eastern hemlock seems to be quite susceptible to drought and sunscorch and combinations of other factors with these. It seems to be a general experience that when the surrounding forest is removed and hemlock is left the opening up of the cover often leads to the drying out of the top soil, so that the hemlock suffers severely. This form of injury may be seen in almost any area where the hemlock has been left and the surrounding trees are removed. It is mentioned by a number of writers.[5]

Winter Injury

The eastern hemlock is apparently very resistant to the various forms of winter injury, and no clearly defined cases of death from this cause alone have been seen by the writer. *Tsuga canadensis* seems to be the most resistant hemlock to winter injury outside of its own range. Baltet[6] found it uninjured in Germany by the winter of 1879-1880, which caused the death and injury of a great variety of trees. Beissner[7] also states that it is hardy in Germany. Saunders, however, found it unsatisfactory in

Manitoba.[8] In a report of the results of a very severe winter freeze in England, Somerville states that there was but a single report of *Tsuga canadensis* being injured.[9] At New York City, Nash[10] found that dwarf forms of *Tsuga canadensis* were winter-killed, but a drooping form was perfectly hardy.

Frost

The hemlock puts out its new growth so late in the spring that it is practically immune to late spring frosts. In the Adirondacks, where spring frosts occur very late in the season, the writer has never seen it injured in the least. It appears to be equally resistant to early fall frosts. Frost cracks sometimes occur in the trunk, but are not especially frequent. Heaving of young seedlings or transplants from the soil by frost is apt to occur with shallow-rooted species like the hemlock.[11]

Lightning

The hemlock seems to be struck by lightning relatively as often as any tree species of the forests where it occurs. Its habit of sending its central shoot high in the air above the surrounding trees is probably the cause. It does not seem to be so badly injured by lightning as some species; usually a furrow is made in the bark and wood, but the top retains its healthy green color and the tree is really but little injured.

Sulphur Fumes

Schenck,[12] who has made a study of the injury to forest trees by smelter fumes, finds that hemlock is one of the most susceptible species, but it is one of the most resistant to discoloration of the foliage.

FUNGOUS DISEASES

The eastern hemlock is comparatively free from serious parasitic fungous diseases. It has no very serious disease in the seedling stage. Damping-off, the great enemy of newly germinated conifer seedlings, is almost unknown as an enemy of this tree species. Although it is in later life subject to a considerable number of troubles, none of these seem to occur in serious epidemics. This may quite possibly be due to the fact that this tree rarely occurs in a pure unmixed stand of any appreciable size. Its scattered distribution in mixed stands undoubtedly must have a considerable influence over the outbreak of disease epidemics, as it quite decidedly hinders the spread of a parasite from tree to tree.

After the tree is dead the situation is quite different. The cut timber of hemlock is very susceptible to decay, especially in contact with the soil.

A large number of wood-rotting fungi are known which attack it, and this number could undoubtedly be largely increased by a systematic and careful search throughout the range of the tree.

In use as fence posts, telephone poles, and railroad ties it is soon rotted, its average length of service being not more than three or four years. It may, however, be successfully treated with chemical preservatives and its length of service greatly increased.[13]

The various fungi attacking the living hemlock tree may for convenience be considered under the following headings:

Fungi Attacking the Cones

But a single fungus is known to attack the living cones—*i. e., Peridermium fructigenum* Arthur. This forms golden-yellow powdery masses of spores which break out over the surface of nearly full-grown green cones. It appears the latter part of June or early in July. Sometimes only a portion of the cone surface is affected, but very often the disease involves the entire cone. It is of some economic importance because the diseased cones soon dry up and fail to produce viable seeds. Most of its known distribution has been worked out by the writer,[14] who has found it in the Champlain Valley, southwestern New Hampshire, and central and northwestern Connecticut. Unsuccessful attempts were made by the writer to inoculate ten different species of Rhododendron and Kalmia with it.[15] Fraser,[16] however, has apparently collected the same fungus in Nova Scotia, and has proved that its alternate host is *Populus grandidentata,* upon the leaves of which host it has been known as *Melampsora medusæ.* It is probable that it will be found upon hemlock in many places where the alternate hosts occur together. Fraser's results seem to indicate that this is identical with *Cæoma abietis-canadensis,* which occurs on the leaves.

Sphærella peckii Saccardo (*S. conigena* Peck) has been found by Peck upon fallen cones of the hemlock. It is evidently saprophytic, since it was found in May, at which time it could occur only upon old cones of the previous year. *S. conicola* Saccardo, also collected on fallen cones, is evidently also a saprophyte.

Fungi Attacking the Leaves

Among the several known parasitic fungi of hemlock leaves, *Pucciniastrum myrtilli* (Schum.) Arthur, (*P. minimum* (Schw.) Arth., *Peridermium peckii* Thümen) is one of the most widespread and abundant. It is distributed from Nova Scotia southward to the mountains of North Carolina and westward to Wisconsin.[17] It has been proved to have an alternate stage of growth upon *Azalea nudiflora, A. viscosa, Rhodora canadensis, Menziesia pilosa, Gaylussacia resinosa,* and *Vaccinium* many spp.[18] Where the two hosts are close to each other the infection of hemlock leaves becomes very heavy, and it may happen that nearly half the leaves of a small tree or of the lower branches of a large tree may be diseased. Such heavy infection is rare, however, and it cannot be said that any appreciable damage is done by this fungus, although it does cause many leaves to fall prematurely. This fungus has been noted and studied in the Northeastern States by the writer, where it has been found to be abundant locally.

The fungus *Necium farlowii* Arthur is another rust which attacks the leaves of the hemlock. It is, however, of rather local distribution, being reported from Massachusetts, New Hampshire, Connecticut, North Carolina, and Nova Scotia.[19] This has been found by Fraser to reinfect hemlock leaves, thus apparently showing that it is autœcious and has but the single host *Tsuga canadensis.* This fungus is only of scientific interest, as it has no particular economic importance. In spite of much search, this fungus has never been collected by the writer.

A third leaf-rust is one known as *Cœoma abietis-canadensis* Farlow. There has been very little published concerning this fungus. Farlow was the first to mention it and to give it its name.[20] It is reported from Massachusetts, Connecticut, and Nova Scotia. It attacks only scattering leaves, and like the preceding is of very minor importance. Fraser[21] successfully inoculated hemlock leaves with spores of *Melampsora medusœ* from the leaves of *Populus grandidentata.* His field observations seem to show that the same fungus attacks the cones and twigs of hemlock also.

The fungus *Keithia tsugœ* (Farlow) Durand is a rather serious local parasite on hemlock leaves. Like the above it is apparently of local distribution, being reported only from New Hampshire[22] and Wisconsin.[23] In a personal letter Farlow states that he has found this fungus in Massachusetts also. Farlow[22] speaks of this fungus as causing a disease which may do considerable harm. It attacks the under side of the leaves, which turn brown and fall quickly. This was found in August and September on a large number of trees and had nearly destroyed the foliage. Davis,[23] on the other hand, is somewhat doubtful about its parasitic nature. This difference of opinion, however, may very well be due to differences in the local conditions where the fungus was found.

A small collection of a parasitic fungus upon hemlock leaves was made by the writer in Bethel, Vermont. The fungus has been identified by the Mycologist of this Bureau as *Hypoderma brachysporum* (Rostrup)

Tubeuf. This fungus has been noted in a number of cases as a rather serious parasite of *Pinus strobus,* but so far as the writer knows the hemlock is an entirely new host for it. Indeed, this is apparently the first report of any species of Hypoderma or Lophodermium upon hemlock leaves. These two genera are the cause of the leaf-cast of various conifers and are apparently active parasites; hence the finding of one of them on hemlock is of especial interest. The fungus was plainly parasitic where found, as it occurred on dead leaves scattered among the living ones on the lower branches of small trees. No particular damage was done, as it was present in only small numbers of the leaves.

There are a number of other fungi which are known to occur on dead hemlock leaves, but so far as the writer knows they are saprophytic.

Fungi Attacking the Twigs

There is apparently only a single fungus known to attack the living hemlock twigs. This is a rust affecting the young growth before it becomes woody. It was found by the writer in several localities in Connecticut, and was tentatively considered to be identical with the hemlock cone-rust *Peridermium fructigenum*[24] specimen which he described was collected in North Carolina by Thaxter. Dr. J. J. Davis recently showed the writer specimens of what is probably the same fungus on hemlock shoots, which were collected by him in Wisconsin. So far as the writer knows, these three localities are the only ones known for this disease. The trouble often kills the shoots; but the number attacked on any one tree is relatively small, and the disease is therefore negligible from an economic standpoint. Fraser's observations and inoculations seem to show that the rust of cones and twigs is identical with *Cæoma abietis-canadensis* on the leaves, and that all three forms are alternate stages of *Melampsora medusæ* on poplar leaves.

Fungi Attacking the Trunk

The hemlock does not have a very large number of fungi attacking the trunk of the living tree. *Trametes pini* (Brot.) Fr. occurs usually in the upper part of the trunk, causing characteristic pitted effect in the wood. The older hemlock trees have been largely cut from the eastern forests for the bark, which is much used for tanning purposes. This undoubtedly explains why this disease is not found oftener in the eastern forests, as it is a disease of mature trees. Schrenk[26] states that the hemlock seems to be the most readily attacked of the common eastern conifers, finding a greater per cent of the old trees of this species affected than of any other. It undoubtedly occurs throughout the range of this tree. It has been noted by the writer in Vermont.

A second fungus which attacks the trunks of hemlock is *Polyporus borealis* Fr. Atkinson has described this as a typical wound parasite.[27] The writer has not found this upon hemlock.

The fungus *Fomes roseus* (Fr.) Cke. has been reported as growing occasionally upon the hemlock. It is known as a parasite of cedar and other coniferous trees, and there is no reason to doubt its occurrence as a parasite upon hemlock. It is usually, however, collected upon dead wood of the hemlock instead of living trees. The writer has never collected this upon living hemlock.

Fomes applanatus (Pers.) Wallr. attacks dead wood in living trees, especially when the trunk has been injured, causing large wounds which are favorable to its entrance. It is not, however, a true heart-rotting fungus, as its attacks are made in dead sap-wood rather than dead heart-wood. It has not been collected on living hemlock by the writer.

Polyporus sulphureus Fr. occurs occasionally upon hemlock. This apparently, however, is rather an accidental occurrence. *Poria subacida* Peck has been mentioned by Schrenk[28] as occurring on living hemlock, and it is quite common upon the dead wood of this species. It is apparently only occasionally a wound parasite, as it has not been seen by the writer attacking living hemlock trees.

Fomes pinicola Swartz is a typical saprophytic wood-rotting fungus; but it is occasionally found upon living hemlock, where it is apparently a wound parasite, entering by means of old knot-holes, branch wounds, fire-scars, and similar injuries.

Fungi Attacking the Roots

Fomes annosus Fr. has been found by the writer attacking the white pine and the pitch pine in New England, and it is known to attack the roots of a number of the conifers. It probably occurs on the hemlock.

Polyporus schweinitzii Fr. attacks many of the conifers and is widely distributed through the forests of the country. It usually makes its attacks at the base of the trunk, rotting out the center and weakening the living tree until it is finally overthrown by the wind.

Armillaria mellea (Vahl.) Quelet attacks the roots of practically all species of trees in the northern forests. It is very abundant and widely distributed and undoubtedly attacks the hemlock. The last three fungi have not been collected upon hemlock by the writer.

Fungi Attacking Dead Timber

As earlier stated in this paper, the dead wood of the hemlock is very susceptible to the various wood-destroying fungi. In fact, it has seemed to the writer that in this respect the hemlock is a sort of intermediate or "bridging" form between the conifers and the deciduous trees, in that we quite often find fungi which are ordinarily limited to the deciduous timbers, attacking and apparently thriving upon that of the hemlock. In fact, such fungi have been noted quite frequently by the writer upon the hemlock, which have not been found upon the wood of any other conifer. Saccardo[29] gives a list of approximately ninety fungi which attack the wood and bark of this tree. Many of these, of course, are of no significance as timber destroyers, and others may be mere accidental occurrences of fungi which grow quite generally upon badly decayed wood of all kinds. Dudley[30] has published a list of wood-destroying fungi found by him upon hemlock railroad ties. He names the following species:

Armillaria mellea.
Agaricus campanella, A. porrigens, A. succosus, A. rugosodiscus, A. epipterygius.
Paxillus atrotomentosus.
Lenzites sepiaria.
Stereum radiatum.
Polyporus benzoinus, P. borealis, P. epileucus, P. medulla-panis.
Poria subacida, P. vaillantii.
Fomes pinicola.
Polystictus abietinus.

The same list was also published under Dudley's name in one of Peck's reports.[31]

Peck has probably collected for the longest time and the most thoroughly of any one who has worked within the range of this tree. In his forty-seventh report[32] he has given a still longer list of Hymenomycetes living upon hemlock timber, which is apparently founded upon his personal observations and collections. He also gives similar lists for *Picea nigra, Abies balsamea, Pinus strobus,* and *P. rigida,* but that for the hemlock is considerably the longest. The fungi mentioned are:

Armillaria mellea.
Tricholoma decorosum, T. multipunctum.
Clitocybe ectypoides.
Collybia abundans, C. platyphylla, C. rugosodisca, C. succosa.
Mycena epipterygia, M. leaina.
Omphalia campanella, O. lilacifolia.
Pleurotus porrigens, P. striatulus.
Naucoria bellula, N. geminella.
Paxillus atromentosus, P. panuoides.
Panus lacunosus, P. stypticus.
Lenzites betulinus, L. sepiaria.

Lentinus lepideus.
Polyporus benzoinus, P. borealis, P. cæsius, P. crispellus, P. epileucus, P. lucidus, P. maculatus, P. undosus, P. weinmanni.
Fomes pinicola.
Polystictus abietinus.
Poria vulgaris, P. subacida, P. vaillantii, P. rhodella.
Trametes cinnabarina, T. sepium.
Merulius himantioides, M. subaurantiacus.
Solenia villosa.
Hydnum farinaceum.
Mucronella calva.
Tremellodon gelatinosum.
Stereum sanguinolentum, S. rugosum, S. radiatum.
Hymenochæte tenuis.
Corticium amorphum.
Dacryomyces deliquescens.
Ditiola radicata.
Clavaria abietina.

Peck has also mentioned the following species in his annual reports as occurring upon hemlock wood or bark:

Corticium suffocatum.
Peniophora glebulosa.
Stereum sulcatum.
Grandinia virescens.
Hydnochæte setigera.
Hydnum arachnoideum.
Mucronella aggregata.
Poria myceliosa.

Ricker[33] has given a number of fungi which have been noted in Maine growing upon this timber. The following species are not included in the preceding lists:

Merulius tremellosus.
Polyporus spumeus.
Irpex mollis.

Farlow and Seymour[34] give a long list of fungi known to occur in this country upon the hemlock. Their list of the Hymenomycetes includes the following species, which are not mentioned in the preceding lists:

Marasmius filipes.
Coniophora suffocata.

Polystictus cinnabarinus, P. versicolor.
Fomes applanatus.
Polyporus giganteus, P. medulla-panis, P. pilotæ, P. resinosus.
Poria tomentocincta.
Radulum pini-canadensis.
Solenia candida.

For a number of years the writer has made quite extensive notes and collections upon the fungi attacking hemlock wood in the Northeastern States, and a number of collections and observations have been made farther south and west by other members of the Office of Forest Pathology. These collections of the writer and his colleagues are listed below in the order of their frequency and apparent importance upon this timber:

Lenzites separia: Maine, N. H., Vt., N. Y., Conn., N. J., N. C., Wis.
Fomes pinicola: N. H., Conn., N. Y., N. C.
Polystictus abietinus: Vt., N. Y.
Polyporus resinosus: Vt.
Ganoderma tsugæ: Vt., N. Y., W. Va., N. C.
Fomes applanatus: Vt., N. Y.
Poria subacida: Vt.
Fomes roseus: N. H., W. Va.
Fomes fomentarius: N. C.
Irpex sinuosus: Vt.
Polystictus hirsutus: N. H.
Panus stypticus: Vt.
Polyporus borealis: Va.

It was earlier mentioned that hemlock is apparently a sort of "bridging" species between the conifers and the deciduous trees for a number of the wood-rotting fungi. Pennington[35] found in northern Michigan *Fomes salicinus* upon hemlock and balsam poplar; *Poria subacida* upon hemlock, spruce, and aspen; *Polyporus sulphureus* upon red oak and hemlock; *Polyporus resinosus* upon maple and hemlock; *Fomes pinicola* upon hemlock, white pine, spruce, balsam, fir, tamarack, and the deciduous species—hard maple, beech, yellow birch, white birch, balsam poplar. Atkinson[36] found *Fomes pinicola* on the three deciduous species—*Fagus ferruginea, Betula lenta,* and *Acer saccharum.* The writer has found it upon *Betula lutea, Acer saccharum, Populus grandidentata, P. tremuloides,* and *Prunus serotina.* The writer has also collected *Polystictus cinnabarina* upon hemlock, and there is no doubt that a number of the other common fungi of deciduous timbers will also attack this species.

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AN IMPROVED METHOD OF INFILTRATING WOOD WITH CELLOIDIN

BY ARTHUR KOEHLER

Contributed

Sections of wood for microscopic study or for photographing through the microscope must be extremely thin. For all ordinary purposes, where low or medium magnifications are used, sections 10 to 12 micra[1] in thickness are sufficiently thin to show details clearly and sharply, but for high magnification sections of from 5 to 8 micra are more desirable. To make sections that are thin and practically perfect over the whole microscopic field, it is often necessary to fill the pores of the wood to be sectioned with some liquid that later becomes solid and offers backing to the cell walls when the knife passes through them. This is true of the broad-leafed woods having soft tissues and of most conifers, especially of conifers having resin ducts, for the thin-walled cells surrounding them are easily dislodged or torn out completely in sectioning, even with a very sharp microtome knife.

Paraffine and celloidin are the materials most commonly used for infiltrating tissues to be sectioned. With woody tissues the use of paraffine is not practical, because it is absorbed by the cell walls and has a hardening effect on them, and it prevents glycerine from later entering the cell walls to soften them. Celloidin is the most satisfactory infiltrating medium for wood, because it enters the cell cavity only, and does not prevent the walls from absorbing glycerine later to overcome hardening due to dehydration with alcohol.

The "Celloidin Method" has been described by Plowman, Chamberlain, C. H. Miller, Stevens, Heller, Thomas, Lee, Bailey, and others.[2]

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[1] One micron equals .001 mm., or .00004 inch.

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The process in each case is practically the same, and is described by one author as "extremely slow and tedious," requiring from 8 to 14 days for its completion. It must be remembered that wood is exceedingly difficult to infiltrate complete by merely placing it in a liquid medium because of the comparatively thick walls and small lumina of the cells. This process should not be confused with that of imbedding objects in a matrix which surrounds the outside only, affording a firm hold, and which can be done in a much shorter time. For the information of those not familiar with the celloidin method as commonly used, the process of infiltrating is here described.

Celloidin is a soluble form of guncotton of high concentration, and though not explosive, is highly inflammable.[8] It comes in thin, horn-like shreds, submerged in water to keep it from deteriorating. When to be used the water is poured off and the celloidin dried of all adhering moisture, after which it is dissolved in a mixture of ether and absolute ethyl alcohol. Some writers state that synthol or absolute methyl alcohol may be used to advantage in place of ethyl alcohol.

After the air has been expelled by boiling from the wood to be sectioned, and the latter has been properly demineralized and softened with hydrofluoric acid, it is dehydrated by leaving it for successive periods in 70 per cent, 95 per cent, and 100 per cent alcohol, each period varying from 12 to 18 hours, according to the size of the blocks treated. The material should be completely dehydrated; otherwise the celloidin will not fill the pores properly and will not harden. From the absolute alcohol it is placed from 8 to 24 hours in equal parts of ether and alcohol, and is then transferred to a vial into which there has just been poured a 2 per cent solution of celloidin in a mixture composed of equal parts of ether and absolute alcohol or synthol. The vial should be tightly corked, and to hasten the process it should be placed in a warming oven at 50° centigrade. After the blocks of wood have been in the 2 per cent solution of celloidin for 24 hours they are placed successively in 4, 6, 8, 10, 12, 14, 16, 18, and 20 per cent solution for 12 to 24 hours each, according to the size of the material used, in order to insure complete infiltration. If it is not necessary to have any more than the superficial cells completely filled with celloidin, some of these steps may be omitted.

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[8] Guncotton is a general name for the nitrates of cellulose. The explosive guncotton is the hexanitrate, $C_{12}H_{14}O_4(NO_3)_6$, and is insoluble in a mixture of alcohol and ether. When ignited it burns quietly, but by percussion it explodes violently. Soluble guncotton, or pyroxylin, is a varying mixture of the four low nitrates, but is chiefly made up of the tri- and tetra-nitrates, $C_{12}H_{17}O_7(NO_3)_3$ and $C_{12}H_{16}O_6(NO_3)_4$. Collodion is a solution of pyroxylin in a mixture of ether and alcohol in varying proportions. Celloidin is a highly concentrated form of pure collodion.

When the 20 per cent solution is reached it is allowed to evaporate slowly till the celloidin is quite firm, but not hard. The adhering celloidin is then trimmed off the blocks, but it should not be trimmed too closely, for a thin covering often holds the edges of the section together in cutting. The material is then placed in chloroform for from 12 to 24 hours to further harden the celloidin. After the chloroform is drained off the material should be placed in a mixture of equal parts of 95 per cent of alcohol and glycerine; it should be so kept for several days, or, if possible, for several weeks, so as to soften the cell walls. The material is then ready to be sectioned.

In the wood structure laboratory of the Forest Service, where much of this work is being done, this process has been shortened considerably by the use of a specially designed apparatus employing air pressure to hasten the infiltration. The time required for the operation is much reduced, and it is possible to infiltrate larger pieces of wood than under the old method.

The apparatus referred to consists of an air-tight chamber connected by means of a stop-cock with an air pump. The chamber is made by clamping with three bolts a heavy glass jar between two brass plates one-fourth inch thick, one plate above the jar and the other below (Fig. 1). The upper plate has a piece of sheet rubber packing glued to its lower surface so as to make an air-tight connection with the rim of the jar. Three holes in the upper plate and packing afford connections for two stop-cocks and a pressure gauge. The object of the stop-cocks is to admit air pressure, relieve pressure, or to change the air. Fresh air may be forced into the jar through one stop-cock, while air charged with the vapor of alcohol and ether escapes through the other.

In the use of this apparatus the wood, after dehydration, is placed into a 10 per cent solution of celloidin in a vial or crystallization dish. A number of receptacles thus prepared are placed, unstoppered, in the glass jar, and this is inserted between the brass plates and made air-tight by screwing down the thumb-screws and closing the stop-cocks. The apparatus is then placed in an incubator or oven having a temperature of 50° to 60° C. Here it must remain for several hours, or until it has been thoroughly heated for some time. This heating causes a rapid mixing of the more concentrated solution of celloidin outside the wood with the alcohol-ether, or later with the less concentrated solution inside the cells; a volatilization of part of the ether and alcohol also takes place, and this produces pressure. When the pressure has been developed for some time it is relieved by opening one of the stop-cocks. Care should now be taken not to let out the gas too quickly, since the formation of

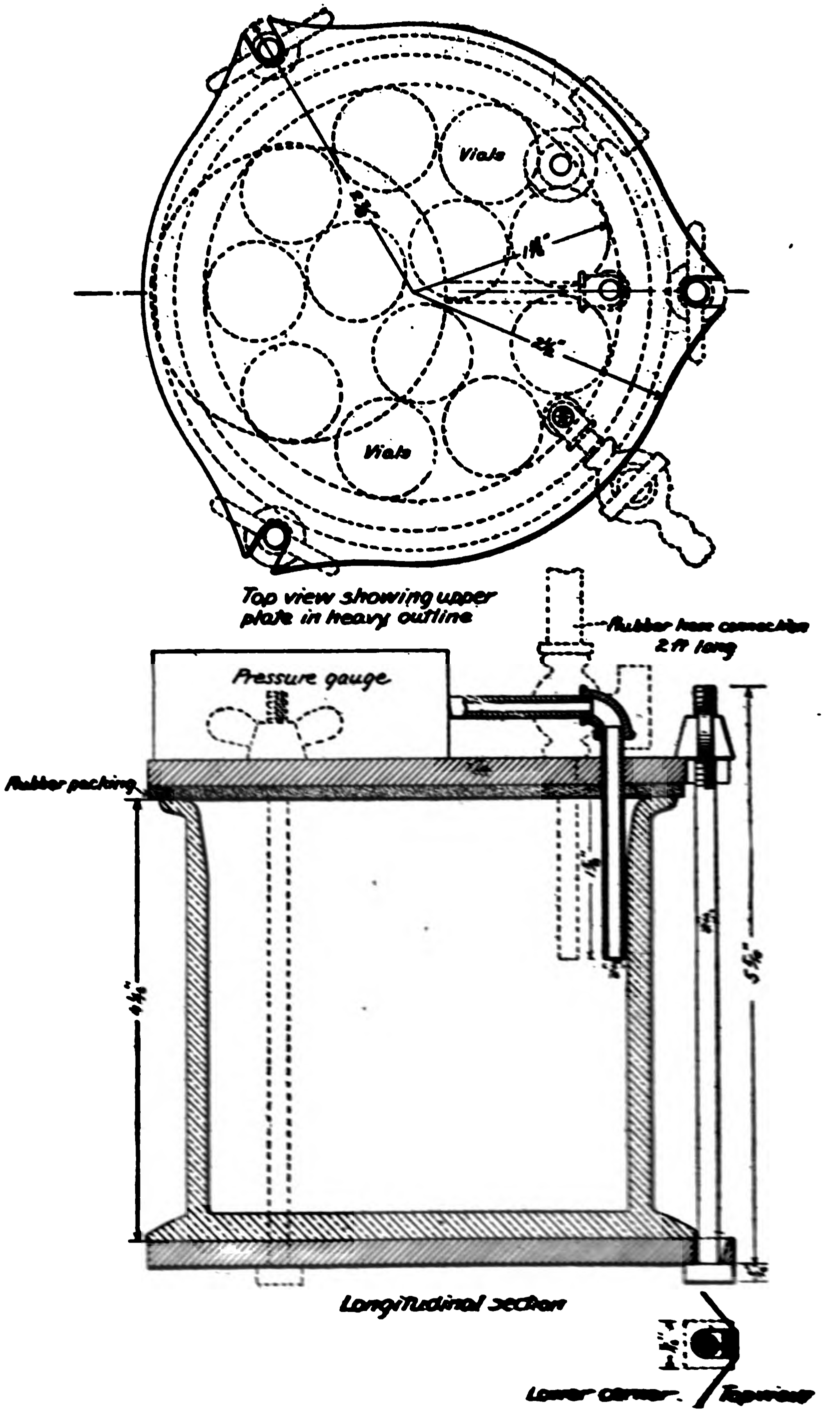


FIG. 1.—Apparatus for Infiltrating Wood with Celloidin under Pressure

bubbles in the celloidin, due to the volatilization of the ether and alcohol when the pressure is relieved, may cause the celloidin to overflow the side of the vessel. After relieving the pressure the apparatus is connected with a foot pump. A pressure of 30 pounds is introduced, and the apparatus is then set into a basin of cold water. The cooling condenses and contracts the celloidin mixture in the cells of the wood, and the pressure forces more of the now thickened celloidin into the pores. When thoroughly cooled the pressure is relieved, and the apparatus, with all openings closed, is again put into the oven and the same process repeated. After five or six of such operations, requiring altogether about 48 hours, the celloidin becomes quite thick in the cells. The containers may now be taken out of the apparatus and the material left to evaporate further till the celloidin is quite firm. Subsequent treatment is the same as under the old method.

Throughout these operations it must be remembered that alcohol, ether, and celloidin are highly inflammable, and when exposed should be kept at least six feet distant from any flame.

THE APPLICATION OF RANGE RECONNAISSANCE TO THE SOUTHWESTERN STOCK RANGES

BY A. D. READ

Contributed

Range reconnaissance is an estimation of grazing resources. It is a stock-taking on the range, as timber reconnaissance is on the forests, and the method of obtaining the information desired is similar in both cases. The data are collected on the ground by uniform, systematized methods.

An examiner, in addition to having a knowledge of stock conditions, should be able to map correctly, to observe closely the different species of forage, and to use care and judgment in deciding the amount of surface covered by vegetation. The ability to do work of this character efficiently depends as much upon natural aptitude as upon instruction. Men excellent in other work may yet be unable to do accurate work in range reconnaissance.

The methods of collecting data in range reconnaissance are similar, as has been stated, to those employed in timber reconnaissance. The information obtained is written up for each section. It consists of a topographic and type map of the area, a list of the herbaceous and shrub species and the amount found, notes on the surface, soil, watering places, and the grazing situation. The most important data collected are those relating to the amount and character of forage and its classification by types. In order to unify the work and to eliminate, as far as possible, the personal element in collecting these data, a system of estimating the amount of forage in tenths of the total 10/10 of the surface covered is used.

A 10/10 ground cover is one on which the herbaceous vegetation grows as thickly as possible; as a heavy blue-grass or grama-grass sod. This perfect condition, with the exception of a few grasses, is rarely obtained, but the amount of ground cover, whatever it may be, is expressed by tenths in relation to it as a standard. If merely one-half of the surface is covered, the density would be 5/10. Furthermore, the vegetation is divided into two classes, palatable and non-palatable; as, for example, a park might have a 5/10 cover of herbaceous vegetation, 2/10 of which would be non-palatable snake-weed and 3/10 palatable grass or forage. The purpose of this division will be seen later.

In timbered areas, that portion on which it is not possible for herbaceous vegetation to grow, due to the actual stumpage area of the timber, dense shade or heavy leaf litter is excluded, and the per cent of herbaceous vegetation is figured on the remaining area. For instance, in a stand of yellow pine, the timber might occupy, to the exclusion of grasses, 2/10 of the surface, while on the remaining 8/10 there would be 4/10 ground cover.

Having examined and mapped an area, the results are tabulated, showing: (1) the total acreage of each type, (2) the amount of palatable vegetation, (3) non-palatable vegetation, and (4) area having no vegetation, all reduced to acres of 10/10 density. A 100-acre park with a 5/10 density of vegetation would have, on being reduced to acres of 10/10 density, 50 acres of vegetation. If, however, 20 per cent of the vegetation were non-palatable snake-weed, these 50 acres would be divided into 40 acres of palatable vegetation, or "forage acres," and 10 acres of non-palatable vegetation. This method of determining the amount of forage on a given area is only an ocular estimate. However, all figures of this character, for any kind of reconnaissance, are based on ocular judgment, and in working up results they must be considered as accurate as it is possible to obtain.

The amount of forage available having been determined, if it is possible to learn how much of it an animal requires for a given length of time, the problem of carrying capacity is solved. The method of determining the quantity needed is to date also an ocular one, being a matter of balancing and comparing different areas. Accurate information on carrying capacity in the Southwest is scarce. Opinions given by old-time stockmen vary widely. It is possible to obtain quite accurate figures in Texas and Oklahoma, where there are many large pastures, but on the open range in New Mexico and Arizona stock drifts so widely that it is difficult to learn just how many head have been using a certain area for a given time.

On the National Forests, however, with the building of drift fences and requiring permittees to hold their stock on their allotments more closely, this difficulty is in process of being overcome. No doubt it will eventually be possible for a ranger to say that "this allotment requires 25 acres per cow for eight months." A range in the Southwest varies so greatly, both in species and the quality even of the same species, that these figures will apply only to the areas on which they were obtained. A stockman, using information acquired in certain localities, can, of course, visit other ranges of like character and estimate the carrying capacity there; but I believe that, by having the area examined by range reconnaissance and using forage acres instead of total acres as a basis for carrying capacity, the method of determination can be simplified and more equal distribution of range secured.

The number of forage acres necessary per head should be determined from some area which is properly utilized—neither under nor overgrazed—and on which the number of stock grazing it through several successive years is known. This area necessarily must have been examined previously and the total number of forage acres on it determined. Ranges fulfilling these specifications, especially for each type, will be difficult to find, and if there are none available it will be necessary to get approximate figures from areas which approach the ideal conditions as nearly as possible.

To make this method more accurate, a carrying capacity factor should be obtained for every type; but until this can be done, I believe that the factor obtained for one type can be used satisfactorily, with little or no change, for all types. In other words, consider one forage acre in the Southwest equal in value to any other forage acre. Some grasses, of course, are more nutritious than others, and some have a longer growing season; but it so happens that here the most nutritious—grama—has the shortest growing season, making, in my opinion, a forage acre of pine grass, which grows from early spring to frost, and a forage acre of grama, which grows only about one-half as long—from the rainy season to frost—almost equal in carrying capacity when compared on the basis of the number of forage acres necessary to carry one animal year long.

I can see no reason why the figures thus obtained could not be used anywhere, at least in the same type, no matter whether it is the poorest range in that type or the best. If it were found that it took seven forage acres of the type "grass, weeds, and browse under timber" to carry a cow one year, an area of 1,000 acres having 490 forage acres would carry 70 cows, while another area of 1,000 acres of the same type, but having a less dense grass cover and containing only 280 forage acres, would carry but 40 cows.

In connection with range reconnaissance on the Tusayan Forest in Arizona last year fairly accurate figures on carrying capacity from several allotments were obtained. These areas were controlled by drift fences, so that the amount of stock on them was known, and the allotments appeared to be completely, but not overutilized. The figures from these several areas checked with each other amazingly well. Other areas which were clearly understocked showed, without exception, a larger number of forage acres per head, while overgrazed areas showed a fewer number. With the exception of the three allotments on which the carrying capacity figures were based, the number of stock grazed was more or less of an estimate, since there was considerable drift on and off the range. Nevertheless, even these figures checked closely, with the exception of a few individual cases.

There were examined on the Tusayan Forest by range reconnaissance 468,000 acres, which were divided among the main types as follows:

	Total acres.	Forage acres.	Non-palatable acres.	Acres supporting no vegetation.
Park	124,000	45,000	9,000	70,000
Browse	12,000	5,000	117	7,000
Timber range	251,000	61,000	5,000	185,000
Woodland range	71,000	15,000	3,000	53,000
Other types	10,000	....	....	9,883
Totals	468,000	126,000	17,117	324,883

This shows the per cent of forage acres to the total acreage to be about 25 per cent. The figures on the carrying capacity for this whole area averaged five foreage acres per cow for eight months, which would be 20 actual acres. These figures may be slightly in error, due to insufficient data as to the number of stock grazed on each area, but I firmly believe that the method of basing carrying capacity on forage acres is a correct and simple one, and that it can and will eventually be worked out by each type if later results show it to be necessary. The factor obtained for each type can then be used wherever the type is found.

Conditions in one portion of the Forest, as shown by range reconnaissance notes and maps, will be indicative of conditions on similar types in another part. A ranger 60 miles away can make a report on a grazing allotment, summarizing it as "containing 1,500 acres of the type 'grass under yellow pine,' which has a 5/10 density of ground cover over the 8/10 surface not occupied by trees." This gives the supervisor an absolute conception of that area—the amount and kind of stock it can carry, when it should be grazed, and the condition of the forage—infinitely better than if the forage had been reported as "excellent" or "medium," "with a carrying capacity of 40 cows." If the supervisor is not acquainted with the area in question, he can undoubtedly find one close at hand which compares in species and density with the type reported on. From this he can form definite ideas concerning the allotment in question.

Under the old system it is necessary for a grazing expert—not always available—to visit each range and make his estimate for that allotment only. Range reconnaissance will obviate this. The only field work necessary will be to determine the number of forage acres by grazing types. It might be thought that, since it is necessary to have a field examination in order to get the number of forage acres, no time or expense is saved—a grazing expert could determine the carrying capacity in place of having the range reconnaissance made. It is easier, however, to obtain men to do range reconnaissance than it is to have capable stockmen who would be available at all times for examining range allotments. Also range reconnaissance, independent of the determination of carrying capacity, is necessary. Every grazing unit should have a correct map showing the different species and amount of forage, watering places, trails, etc., in order to facilitate the administration of grazing both at present and in future, as well as to make possible efficient development and improvement.

It is thought that entire Forests can be examined and the figures obtained and used several years later, supplemented by a brief survey at that time.

DAMAGE TO REPRODUCTION BY SNOW

BY RICHARD H. BOERKER

Contributed

Damage to forests by snow is a matter that has been given but little consideration in the past, although no one who has traveled through the timber in the regions of heavy snowfall has failed to observe its effects. The purpose of this investigation, therefore, was to secure, if possible, a little definite information as to just what extent in forest management snow damage must be considered.

For the purposes of this study, a sample plot was established in June, 1911, on the Lassen National Forest at an elevation of about 5,000 feet. A representative area was first selected in an open park-like stand of mature yellow and Jeffrey pine, where the reproduction was fairly heavy. A sample plot 100 feet square was then laid off and a tally made of the trees and of the injuries they had received. The plot selected was on a moderate north slope and represented conditions typical of the locality.

In all there were 159 trees under 10 feet high on the area selected. Of these, 66 were under 2 feet in height and were practically uninjured, having been covered by the early snows, which probably protected them from damage by the heavier snowfalls occurring later in the season. Of the 93 trees between 2 feet and 10 feet in height, however, 62, or 40 per cent of the total number under 10 feet, were more or less injured. The nature of these injuries is shown in the following summary:

1. Fractured stems, the result of a bending force applied to the whole tree; bark and cambium split horizontally on the convex side of the bend; outer wood fibres ruptured; bark and cambium split horizontally and vertically on the concave side, leaving a corrugated surface; wood fibres crushed	39 trees
2. Leaders fractured as in No. 1, which will either recover by themselves or their places be taken by a lateral branch	6 trees
3. Trees with fractured branches, similar to condition of fractured stems above, varying from 1 to 8 branches per tree, fracture usually near the stems	44 trees
4. Trees with broken branches or branches pulled out of the main stem clear to the heart, leaving a large open wound in the stem, branches dead or dying	25 trees
5. Broken stems, same conditions as in No. 1 above, much more serious; stem buckled, cambium and wood fibres torn	6 trees

From the above classification it will be seen that there were in all 120 injuries, averaging two per tree. In reality there were many more, as a tree having five broken branches on it was classified as having only one injury.

It should be noted in connection with the above data, however, that the winter of 1910-1911 was exceptionally severe, the snow reaching a depth of 27 feet, where in ordinary winters 15 feet is the maximum.

An examination of the sample plot in November, 1911, showed the following results:

One tree on the plot had died, having been broken off near the base. The terminal buds of three others were dead, but in each case side branches were taking the place of the leader. The wounds in the two trees which had been broken midway up the stem had healed over. The leaders of these trees, however, were growing at nearly right angles to the stems, the trees having never regained an upright position. Where branches had been pulled out of their sockets they had died, but in every case the wounds had healed over and no indications of insect or fungus attacks were in evidence. The remaining trees apparently had fully recovered and showed no ill effects from the severe bending they had undergone.

From this it might seem that the actual damage due to snow is of little consequence and that it need not be given serious consideration. As a matter of fact, however, 9.7 per cent of the trees damaged, or 6.6 per cent of the total stand between 2 feet and 10 feet high, are shown to have been killed or permanently deformed. While the balance have apparently recovered, there remains the question whether they have not been weakened to such an extent as to render them liable to serious injury in the future. In any case, it will be seen that snow is a factor of considerable importance in certain regions and one that is largely responsible for the large number of deformed saplings and poles found in the regions of heavy snow.

THE USE OF WOOD IN GAS PRODUCERS

BY ROLF THELEN

Contributed

Although producer gas has been used for the generation of power for many years, it was not until the present century that producer-gas power assumed commercial importance in the United States. In the year 1900 there were about 2,000 horsepower being generated from producer gas, and at the present time producer-gas power plants approximating a total of 200,000 horsepower are in operation in this country. Practically all of these plants, however, are operating upon anthracite or bituminous coal.

Tests conducted over a period of years by the U. S. Geological Survey, and later by the Bureau of Mines, have demonstrated that many kinds of lignite can also be used successfully in the gas producer, and there are now a number of plants in the West and South which are operating upon this class of fuel.

Producers using wood as fuel have been operated with marked success in various parts of the world, but economical conditions in America have been such that the use of this fuel has increased but slowly since the first plant was installed at Nacozari, Sonora, Mexico, in 1900. In the eastern manufacturing centers coal has been so cheap, comparatively, and the supply so reliable that the use of wood has not been economical; and in the West, where thousands of tons of wood waste are burned every year, cheap water-power is supplying the power needs of the coast cities.

Sawmills use steam power exclusively on account of the cheaper first cost of steam installations, the cost of fuel being considered as nil.

As soon, however, as profitable methods of utilizing saw-mill waste become commercial realities, and this waste takes on an appreciable value, the necessity for more economical production of power will become a problem with sawmills and wood-working plants. At present the more waste burned under the boilers the smaller the refuse burner needs to be.

As soon, also, as the price of coal rises much higher than at present, the transportation of wood fuel over much greater distances will become practicable and the availability of this fuel will increase accordingly.

Economic conditions in various parts of the United States and Mexico are even now such that the use of wood in gas producers gives the best solution to the power problem.

At least five plants in Mexico are reported to be operating upon wood gas. These plants are remote from railroads, and in one case it was necessary to haul coal 90 miles by wagon. This distance has since, however, been materially reduced by railroad extension. The supply of wood was limited and of poor quality and had to be packed in from the surrounding country on burros, but under the conditions wood was much cheaper than coal, and the greater fuel economy of the gas-engines more than offset the cheaper first cost of a steam plant. Furthermore, the greater water economy of the gas plant was very much in its favor.

One producer-gas plant in Louisiana, after trying several kinds of coal, found that wood gave better satisfaction all around, and that it was cheaper as well. Another plant in Georgia burns either wood or coal interchangeably, depending upon the supply of wood at hand.

A good compound condensing steam plant will develop one brake horsepower for one hour upon 3¼ pounds of coal. A producer-gas plant will generate this same amount of power upon less than 1¼ pounds of the same coal. This comparison will indicate the relative fuel economy of the two types of power producer.

Although there is a dearth of data on the subject, the data which we do have indicate that a producer-gas plant operating upon wood fuel will produce a brake horsepower for an hour upon an average of 2½ pounds of dry wood. It is believed that this is a very fair average figure and one which can be obtained readily in practice. Further, a comparison of calorific values of wood and coal shows that wood has a heat value about one-half that of good coal; so that it would be reasonable to assume that a pound of coal would generate about twice as much power as a pound of wood. It may not be amiss to state that the fuel value of dry non-resinous wood per pound is practically constant, irrespective of species.

All of the wood-burning producer-gas plants in America which have come to the writer's notice have used this fuel successfully. Most of these plants are of the Loomis-Pettibone down-draft type and burn the wood in the shape of half-cord lengths or blocks, usually in the air-dry condition. The larger producers can use full cord lengths satisfactorily, and successful operation has been reported on bark and refuse of odd shapes and sizes.

The Louisiana plant, to which reference has been made, is equipped with Taylor producers of the up-draft type, and has successfully gasified wood fuel consisting of half sawdust and half chips, with moisture content of from 35 to 55 per cent. An occasional charge of blocks was fired to fill up holes and chimneys in the fuel bed. The mechanical extraction of the tar from the wood gas was much easier than that of a tar from bituminous coals; in fact, the plant was run for a period of about a week without the tar separator, this machine being laid up for repairs.

To adapt the Taylor producers to the use of wood fuel, it was merely necessary to substitute a large tapering cylinder for the charging hopper used for coal. The Loomis-Pettibone producers need no change whatever and can be fired upon wood or coal interchangeably or upon a mixture of these fuels. Further, reported results show that full horsepower capacity can be obtained from wood fuel.

To summarize:

(*a*) The producer-gas plant is much more economical in fuel and water than the steam plant and seems to be equally as reliable.

(*b*) The substitution of producer-gas plants for steam plants becomes economical when the saving in fuel is great enough to obliterate the difference in fixed charges due to the higher first cost of the gas plants.

(*c*) The use of wood fuel in producer-gas plants will be more economical than the use of coal when the cost of the latter rises appreciably above twice the cost of the former.

THE DISTINGUISHING FEATURES OF THE TRUE FIRS (*ABIES*) OF WESTERN WASHINGTON AND OREGON

BY E. J. HANZLIK

Contributed

Owing to the confusion in the field concerning the four true firs—noble fir (*Abies nobilis*), amabilis fir (*Abies amabilis*), grand fir (*Abies grandis*), and Alpine fir (*Abies lasiocarpa*)—found in the western parts of Washington and Oregon, it is the purpose of this discussion to bring out the main differences between them in an unmistakable manner.

These differences are based upon the bark, leaves, cones, and bracts, either of which alone is sufficient to distinguish the species after a tree stage has been reached (above 10 inches in diameter). In order to simplify the description, these characters will be taken up separately and discussed for each species.

THE BARK

The bark is first in evidence in a forest, and by its character the species should be known, especially in reconnaissance work. The principal characteristics are as follows:

Noble fir (*Abies nobilis*)

Color.—Ashy gray on young trees; dull, reddish purple on mature trees; brighter red on cut faces.

Character.—Lightly furrowed on young trees; on old trees divided by narrow seams into flat, narrow ridges, broken into long, irregular plates; bark comparatively soft.

Thickness.—1¼ to 1¾ inches, rarely over 2 inches, on mature trees.

Amabilis fir (*Abies amabilis*)

Color.—Ashy gray, with characteristic blotches noticeable along the bole on young trees; decidedly gray on old trees; inner bark a deep vermilion color, with a tendency to "bleed" when cut into.

Character.—Remarkably smooth, with numerous resin blisters on trees under 24 inches in diameter; old trees usually slightly seamed at butt, the bark somewhat scaly, but smooth and regular higher up; bark comparatively soft.

Thickness.—Comparatively thin; usually thinner than noble fir bark on trees of equal age.

Grand fir (*Abies grandis*)

Color.—Ashy gray on young trees; pale red brown on mature trees; bark on trees over 12 inches in diameter sometimes rather pale brown.

Character.—On trees under 20 to 24 inches in diameter, regularly and shallowly furrowed; on mature trees deeply and narrowly furrowed; bark comparatively hard.

Thickness.—On young trees about 1 inch thick; on mature trees rarely over 3 inches thick.

Alpine fir (*Abies lasiocarpa*)

Color.—Light ashy gray.

Character.—Smooth; occasional shallow narrow cracks near the base on old trees.

Thickness.—½ to ¾ inch; sometimes 1¼ inches on mature trees.

RÉSUMÉ OF BARK CHARACTERISTICS

Grouping the species as they are associated in the different types, we have: (1) amabilis fir and grand fir competing in the lower slope type; (2) amabilis fir and noble fir in the upper slope type; (3) noble fir and Alpine fir in the Alpine type.

Taking these in order, the distinctions are as follows:

Species.	Color.	Character.	Thickness.
Amabilis fir.	Blotches ashy gray on young trees, dark gray on mature trees. Inner bark deep vermilion color; "bleeds" when cut into.	Young trees smooth, with resin blisters up to about 24 inches diameter; old trees slightly seamed at butt, somewhat scaly, smooth higher up.	Rarely over 1½ inches on old trees.
Grand fir.	Young trees ashy gray, no blotches; sometimes pale brown, old trees pale red brown.	Young trees regularly and shallowly furrowed; old trees deeply and narrowly furrowed.	Trees 18 to 20 inches, rarely over 1 inch thick; on old trees about 3 inches, rarely more.
Noble fir.	Young trees ashy gray; old trees dull reddish purple, bright red on on cut faces.	Young trees lightly furrowed; old trees divided by narrow seams into flat, narrow ridges broken into long irregular plates, flaky.	On old trees 1¼ to 1¾ inches, rarely over 2 inches.
Alpine fir.	Light ashy gray........	Young trees smooth; old trees remarkably smooth, with occasional narrow cracks near the base.	Rarely over ¾ inch thick.

THE LEAVES

The species of the Abies bear two different leaf characteristics, those of the lower crown being decidedly different from those of the upper crown. Therefore, both forms will be discussed. On the basis of the leaves, the species in western Washington and Oregon may be divided into two classes:

I. Amabilis fir and grand fir;
II. Noble fir and Alpine fir.

This division is made upon the manner in which the leaf is attached to the twig or branch—in the first class there is a decided twist in the leaf near the leaf base; in the second class the leaf is perfectly straight, without any decided twisting near the point of attachment. This twisting or non-twisting characteristic holds good for leaves on all parts of the crown.

I. *Leaves with decided twist near their bases.*—Taking each class by itself, we have first to distinguish between amabilis fir and grand fir. These two species have the following in common:

1. *The leaves have a decided twist near their bases.*
2. The leaves grow out from all sides of the branches.
3. The leaves are more or less flattened in cross-section.
4. Leaves of the lower crown are grooved on the upper surfaces and notched at the tips; those of the upper crown are grooved and bluntly to sharply pointed.

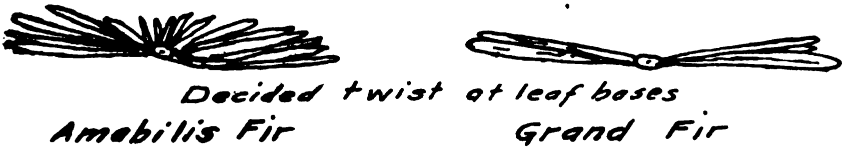
The differences based on the leaf characteristics are as follows:

1. *Amabilis fir.*—Leaves of the lower crown, due to the twist at their bases, *appear as if growing from the two sides and top of the branches, causing the leaves to bunch on the upper side of the branches;* leaves 1 to 1½ inches long, deep rich green, particularly silvery underneath; leaves of the upper crown massed on upper side of branches.

2. *Grand fir.*—Leaves of the lower crown, due to a twist at their bases, *appearing to grow out from the two opposite sides only, presenting a flat, two-ranked, horizontal appearance;* leaves of the upper crown more or less crowded together, pointing upwards; foliage bluish green; leaves ordinarily 1 to 1½ inches long.

The principal distinction is in the manner in which the appearance of the leaves of the lower crown of amabilis fir differs from that of the leaves of grand fir, in the latter species presenting a decidedly two-ranked horizontal appearance, while the amabilis fir shows the leaves as massed on the top, in addition to appearing as if growing out on the two sides. Diagrammatically we can show the manner in which the leaves appear to grow out from the branches as follows:

Cross-section through stem from lower crown:



The foliage of grand fir is much less dense than that of amabilis fir growing under similar conditions.

II. *Leaves not twisted near their bases.*—The principal characteristics in common for these two species are (noble fir and Alpine fir):

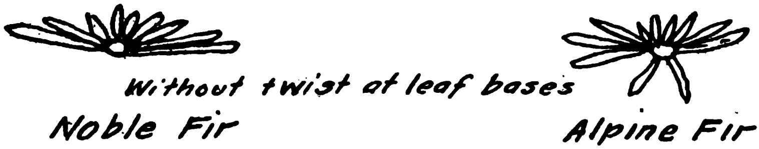
1. *The leaves are without a twist near their bases.*
2. The leaves grow out from all sides of the branches.
3. The leaves of the lower crown are flattened in cross-section and usually notched at the tips; those of the upper crown are more or less diamond-shaped and bluntly to sharply pointed.
4. All leaves are grooved on their upper surfaces.

The distinctions between noble fir and Alpine fir are as follows:

1. *Noble fir.*—Leaves of the lower crown are curled so as to appear as if growing out from *the two sides and the top of the branches* (*none appearing as if growing directly downward from the under side*); leaves of the upper crown are curled stiffly upwards; foliage pale to bluish green, silvery underneath.
2. *Alpine fir.*—Leaves of the lower crown curled so as to *appear as if growing from all sides* (*top, two sides, and bottom*) *of the branches, those from the under side rather few and growing straight downward;* foliage deep bluish green, ¾ to 1¼ inches long on lower crown, ⅝ to 1 inch long on upper crown; latter curled stiffly upwards.

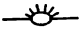
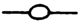
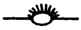
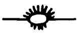
This brings out the principal difference in the manner of the appearance of the leaves on the branches, those of noble fir appearing as if to grow out from three sides—top and two sides—those of Alpine fir as if growing out from all four sides.

A cross-section cut of a stem shows the following arrangement of the leaves:



RÉSUMÉ OF THE LEAF CHARACTERISTICS

In the field usually it will be desired to distinguish amabilis fir and grand fir from each other, amabilis fir from noble fir, and noble fir from Alpine fir. Grouping these species under one head, the distinctions show up as follows:

Species.	Twisted at leaf base.	Diagrammatic arrangement of leaves on stems.	Length of leaves (inches).	Remarks.
Amabilis fir....	Yes.		1—1½	Leaves more or less flattened in cross-section on all parts of crown.
Grand fir.......	Yes.		1—1¾	Do.
Noble fir.......	No.		⅝—1¼	Leaves of lower crown more or less flattened; those on upper crown more or less diamond shape.
Alpine fir.......	No.		⅝—1¼	Do.

THE CONES AND BRACTS

Using the cones and bracts as a basis of distinction, these four species fall into two groups:

I. Cones with bracts that are longer than the scales covering the outside of the cone—*noble fir.*

II. Cones with bracts that are shorter than the scales and do not show on the outside—*amabilis fir, grand fir, Alpine fir.*

In addition to these main differences, the following additional descriptions are appended:

I. *Bracts Longer than the Scales*

1. *Noble fir.*—Cones 4½ to 7 inches long, cylindrical, over twice as long as broad; bracts of cones with very long tapering points, usually covering the outside of the cone completely.

II. *Bracts Shorter than the Scales*

1. *Amabilis fir.*—Cones purplish, 4 to 6 inches long; less than twice as long as broad; bracts of cone-scales gradually narrowed into long, tapering points.

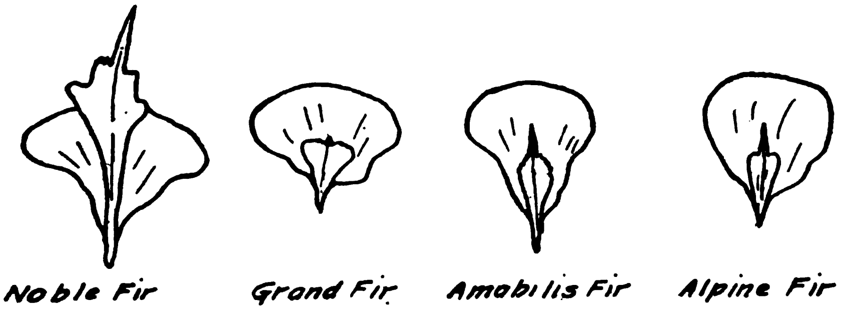
2. *Grand fir.*—Cones greenish, 2 to 4½ inches long; usually 1½ to 2½ inches thick; bracts of cone-scales with either rounded or flattened shoulders and short, abruptly pointed tips.

3. *Alpine fir.*—Cones purplish, 3 to 5 inches long, 1 to 2 inches thick; bracts of cone-scales with abruptly rounded shoulders and long, gradually tapering tips.

RÉSUMÉ OF THE CONES AND BRACTS

The main points of distinction by the above characteristics are as follows:

Species.	Cones.			Bracts.	
	Color.	Length (inches).	Thickness (inches).	Extruded.	Character.
Noble fir.......	Purplish.	4½ to 7	2½ to 3	Yes.	Long, tapering points; abrupt shoulders; irregularly notched; completely covered cone.
Amabilis fir....	Purplish.	4 to 6	2 to 3¼	No.	Shoulders gradually narrowed into bluntly tapering tips; irregular notching.
Grand fir......	Greenish.	2 to 4½	1½ to 2½	No.	Short tips; shoulders rounded or squared; distinctly notched.
Alpine fir......	Purplish.	3 to 5	1 to 2	No.	Shoulders abrupt, with long, tapering, sharp tips; practically no notches on shoulders.



Cone scales and bracts.

REVIEWS

DER BLENDERSAUMSCHLAG UND SEIN SYSTEM[1]

This review pretends to no originality, for I feel sure that the Society will prefer the opinion of so competent an authority as Professor Dr. Beck, of the Royal Saxon Forest Academy at Tharandt, to my own. Furthermore, only one who is in intimate touch with all the recent developments of forestry in Germany can pass reliable judgment upon so important a work as is this of Wagner's.

I translate, therefore, excerpts from Dr. Beck's review in the May, 1913, number of the "Allgemeine Forst- und Jagd-zeitung" (pp. 165-175). For greater convenience, quotation marks are omitted.

The author builds on the premise that the best forest management demands a unified system. This system has two foundations: order in regard to area and order in regard to time.

As set forth in his first epoch-making work,[2] Wagner is not in agreement with the area arrangement effected by the present systems of management, since they result in even-aged, pure stands of large size, with their many detriments. To prevent these, he seeks a system of management which, while free from these detriments, can still find universal application. He reaches the panacea: "Blendersaumschlag," which, while more literally translated "selection-strip (or 'seam') cuttings," I have ventured to paraphrase "border-cuttings."

Answering the inevitable criticism that no one method can be of universal applicability, Wagner once more reviews his method and insists that by means of it a correct, *natural* arrangement of the forest can be brought about without undue sacrifices, and that the longing for natural regeneration and mixed stands can be fulfilled.

So in his new work Wagner unrolls the picture of a forest systematized according to his method. Wagner's enthusiasm for his method is contagious. But the book is more than a "High Song of Blendersaumschlag." Everywhere are evidences of independent thinking and a boundless love for the forest.

The book is divided into three parts. The first part deals with the single cutting area, and is virtually a recapitulation of the material contained in his previous book. The progress of regeneration of "Blendersaum" cuttings is primarily from the north to the south. This progress can be likened to the reading of a printed page, where the eye sweeps from top to bottom, line for line, steadily withal, yet halting occasionally until some difficult passage has been mastered. However, Wagner emphatically denies that his system is utterly dependent on a reproduction along the north border of stands. He merely asserts that wherever it is applicable natural reproduction along the northern border surpasses all others in total results obtained.

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[1] C. Wagner: Pp. 368, text figures 73, plates 2. H. Laupp, Publisher, Tübingen, Germany.

[2] "Die Grundlagen der räumlichen Ordnung im Walde." Briefed "Forestry Quarterly," Vol. VI, pp. 160-162; Vol. VIII, pp. 366-368; Vol. X, pp. 699-705. See also Proc. Soc. Am. Foresters, Vol. VII, No. 2, pp. 145-152; reprinted 1912.

This claim is not susceptible of immediate proof or contradiction. The decision must come from the results of practice over long periods of time, not through mere reasoning. Wagner's system is essentially one of small-area management in opposition to the large-area management of today. In this combat lies the greatest interest in his system, and from it will probably flow the best results.

In describing the advantages of his own method Wagner depicts the faults of the other systems somewhat too darkly. Furthermore, the optimum conditions for natural regeneration which Wagner describes as occurring on the north border of stands would seem to point to such ideal sites and climate that, with them, even the large-area methods would result in satisfactory natural regeneration.

Wagner's axiom, "the northern border of forests, under proper reproduction cutting, offers the best site for the natural regeneration of all species, regardless of their respective tolerance," he elucidates only for the truly tolerant species, beech and fir, which also reproduce naturally under other systems, and for the semi-tolerant spruce. To overcome this lack, Wagner emphasizes the need of careful experiments with all kinds of trees. These experiments are especially needed in Scotch pine.

Blendersaumschlag results not in pure but in mixed stands. This point must not escape the reader's attention, lest he misconstrue much that Wagner says. On page 80 Wagner points out that pure stands are comparatively difficult to regenerate by means of their own seed owing to insufficient seed production, and hence his system may secure only partial satisfaction in pure stands.

The mixture of species is to be complete, *i. e.*, singly or in small groups, not in large groups ("horstweise"), since the latter are uneconomical, even though silviculturally advantageous. This mixture, Wagner claims, is achieved automatically by his system, although cleanings and thinnings are needed to bring about a proper interrelation of species in the young stand. That to secure this result involves too much expense, and hence is just as uneconomical as the large groups, Wagner controverts by saying that the difference in ages of the young growth will give free play to the law of natural selection. This expectation is hardly justified, since that species is apt to predominate whose growth requirements are best fulfilled; to counteract this requires an expenditure of money for cleanings and thinnings, if the desired species and individuals are not to be suppressed.

Wagner claims (p. 258) a close relation of his system with that of Mayr's "Kleinbestandswirtschaft." If this be so, it merely proves that extremes often meet!

No doubt correct silvicultural practice is easier on a single narrow-cutting area, as recommended by Wagner; but if one considers that it requires, for example, 10 such small areas to equal the cut of one large one, the advantages of Wagner's system may be counterbalanced by the easier work on and supervision of one single, large-cutting area. The author, it is true, combats this on page 305 ff., but hardly with success.

Excellent are the remarks on the character of seed (p. 124) and the necessity of more silvicultural activity on the part of forest supervisors, often sunk too far in mere routine administration. But Wagner goes too far when he (p. 303) says that the academically trained man is alone equipped for the practice of silviculture; this is bitterly unjust to many an experienced subordinate officer.

In the second part Wagner describes in detail how a forest, hitherto managed under a large-area system, will look under his own small-area system and how the transformation from one to the other is to be effected.

The unit of area in a forest built up on Wagner's system is the cutting series ("Schlagreihe")—*i. e.*, the area lying between two initial border cuttings. In this area the age decreases in the direction of cutting, and since the system is linear rather than blockwise the profile would be not a series of steps, but like a right-angled triangle.

The cutting series begins with a line of attack. For this Wagner says: "No line of attack must stand still, but must be kept in constant motion." Until this becomes a practical possibility the results will be almost identically those of Judeich's "Bestandswirtschaft," with its cutting series composed of several stands.

The cutting series are bounded in level country by two parallel systems of compartment lines: one in the cutting direction, the other at right angles thereto. This permits of forming protective windmantles on the endangered borders (especially the west side), so that each cutting series may be an independent unit. The compartment lines serve as roads and are to be about 13.12 to 16.40 feet wide (4 to 5 meters).

Along these roads the windmantle in coniferous forests is to consist of strips 32.8 feet (10 meters) wide planted to oak. Windmantles are especially needed on the west and south borders of the cutting series. The oak rotation is to be twice that of the conifers.

Wagner's claim that his system secures the simplest area arrangement conceivable will not hold true, since the clear-cutting methods certainly leave nothing to be desired in simplicity of area arrangement.

In the second chapter of this part of his book Wagner considers the relation of his system to the time-element in regulation of yield. Wagner bases the yield determination upon the age-class relation, an exact knowledge of which therefore becomes necessary. This presupposes that the age classes are distinct by area. But Wagner will have nothing to do with distinct age classes in the forest lest it lead to the idea of "stands." There are no "stands" in Wagner's philosophy, but only cutting series ("Schlagreihen"). However, within these there are even-aged areas which, though of least extent and of obscure demarcation, are regular in form and of which the area can easily be measured.

This measurement of the age-class areas occurs only one time. Every ten years, at the time of yield regulation, the dividing line between old growth and young growth is fixed for the ensuing ten-year working period, and so entered on the map where the areas can be planimetered. This map, therefore, shows the boundaries of the 10-year age classes and furnishes the basis for an age-class table. For the purposes of calculating the growing stock of yield distribution and of a record of cuttings the age class approaching maturity is marked in the woods by painting the border trees or, better still, by cutting through a woods—road along the boundary. The idea of a "stand" is, therefore, not so foreign after all to Wagner's system as long as one does not cling to the narrow definition of "stand" given on page 182.

Current calculations of growing stock, increment, final and intermediate yields, costs of production, etc., are based on so-called index-cutting series ("Weiserhiebszüge")—that is, averages chosen to represent the entire forest.

The allowed annual, respectively periodic, cut is to be based upon the normal annual cutting area (total area divided by rotation age) and on a comparison of the actual with the normal distribution of the age classes. The object is to bring about quickly and with minimum sacrifices a normal distribution of the age classes. The volume standing upon the areas to be cut during the ensuing 10-year working period is determined either by calipering or by means of yield tables (or by measurement of average trees) and, with the addition of the increment for five years (half the working period!), constitutes the allowed periodic volume of final cuttings.

In all essentials, therefore, the regulation of yield in Wagner's system coincides with that of the Stand Method.[3] Even the plan of cutting for ensuing working period finds its analogy in the provisional distribution of yield among the various cutting series.

In the third and last part of the book Wagner treats of the transformation of existing systems of management into his one of Blendersaumschlag. He recognizes fully the difficulties to be met in this transition and warns immediate attempts at an ideal condition; advises contentment with what can be secured locally without sacrifices, and counsels patience in the transition stage, since the greater the discrepancy between present conditions and desired results the longer the period of transition.

The distance between two points of attack—in other words, the number of cutting series—Wagner makes dependent on the character of the forest. The more even-aged and purer the forest the more points of attack are needed, if the regeneration of the individual cutting series and with it the formation of the desired age-class distribution is to be achieved without great economic sacrifices. In even-aged forest the distance between points of attack is to be from 656 to 984 feet (200 to 300 meters), with a width of 1,312 to 1,640 feet (400 to 500 meters). The single-cutting series would, therefore, contain only 19.76 to 37.05 acres (8 to 15 hectares)! Wagner follows this statement with a warning against making too minute divisions and advises broad, preparatory cuts, which, while scarcely corresponding to the linear principle of his system, is certainly in closer accord with practical needs. With a rotation of, say, 80 years and an average cutting series of 28.41 acres containing all-age gradations from 0 to 80, the normal annual cutting area would be only $\frac{28.41}{80} = .355$ acres; surely a small-area management of almost unattainable intensity!

This new work of a gifted author is too rich in content and too unique in character to do it justice in all directions. It contains, besides much that is doubtful and debatable, so much that is good and worth noticing that even the casual reader will gain therefrom inspiration and profit.

A. B. RECKNAGEL.

ITHACA, N. Y., JANUARY, 1914.

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[3] See Lorey: "Handbuch der Forstwissenschaft," H. Laupp, Tübingen, 3d edit., 1912, Vol. III, p. 392 ff., p. 430 ff.; also "The Theory and Practice of Working Plans," John Wiley and Sons, N. Y., 1913, pp. 84-89.

Logging[1]

Among the various readers of Professor Bryant's book there will necessarily be those who will have very different feelings about it; who will look at it from very different angles. Some few probably will look for enthusiasm for the subject and the men whose work is recounted. We know well the old forestry view of the lumberman; that he is a despoiler of the country's natural resources. Professor Bryant, of course, has long been beyond that, if he ever shared it. A man, then, with a free mind, who has had opportunity to review the work of the men in the most characteristic American industry, whose ancestors perhaps were lumbermen, who has heard the stories of the road and the drive in New England, seen the ingenuity exerted in conquering the swamps and mountains north and south, has associated with the keen, jovial, daring men who are today pushing ahead the methods of logging on the West coast—a man with this behind him, one would think, even if he did not design it, would at some point have been overrun by enthusiasm. Perhaps enthusiasm is behind the book, but it is not evident in it. The dedication is on another order altogether. Some men would have appreciated evidence of this in the general attitude and viewpoint.

Perhaps that was not fairly to be expected, however. In the preface it is expressly stated that the work is designed as a text-book for use in forest schools. Looked at from that point of view, the book is certainly a landmark. Courses in "lumbering" to date, according to the best information available, could not always be called entirely adequate. Now a man who has had several years to devote to the subject, who has been all over the country and carefully inquired and observed, writes out what he has learned about one branch of the industry in an orderly and systematic way, putting a vast fund of information in a book where it can be got at. Few will realize the volume of painstaking work involved or appreciate the thinking which lies behind the presentation. One good feature of the book is what is left out of it. There are limits to the possibilities of communicating information in this form. It would have been very easy to lumber up a volume with a mass of details that would be useless and confusing. Assuming, therefore, the large usefulness of the educational plan which inspired it and into which it fits, Professor Bryant has certainly done a great service. Not only that, but it is believed that men in active business will find the work worth their examination for the broad view it gives of methods and appliances used in and adapted to different sections and circumstances.

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[1] By R. C. Bryant. John Wiley & Sons, New York.

Looked at from other angles, the following may be noted: Some one in Chicago is said to be producing a series of books on the various industries in companion volumes, the "how" series and the "why" series. Looked at from this standpoint, "Logging" is mainly in the first classification. Mainly, it is said, not entirely and by intention; but it would not have been unnatural, for instance, to look in a book of this kind for a broad treatment of natural conditions as determining the general plan and lay-out of operations. Again, no reference has been noted in the work to the relation of the different logging methods or the financial situation of property-owners to the conservative cutting of timber, a subject in which forest students might be thought pointedly interested. Possibly indeed these matters are of the class which should be left out of a text-book. Of the two series of works the descriptive one comes first, anyway.

Another line of comment is suggested by a recent address delivered before the senior class of the school in which Professor Bryant teaches on the theoretical *versus* the practical. Doctor Fernow has had very wide experience not only of forestry, but of life, and his emphasis is laid not on the value of specific information acquired in educational courses, but on acquiring the right concepts and the habit of thinking.

Applying this principle to the work in question, the following suggestion arises: Logging in itself is essentially engineering. That is illustrated most effectively today by affairs on the West coast, where engineers are leading in the executive field and specialists in electric and other branches of engineering are being called to the assistance of the industry. The most effective training for actual efficiency, then, may not prove to be that which has as its main material of instruction the phenomena of the industry itself, but that which teaches the fundamental sciences and cultivates the habits of thinking and reaction which the work requires. That again, however, is not set up as a test or criticism.

It is stimulating also to think of the relation of this book to loggers and what it may mean to them one way and another in present and future, for back of all our writing is the great industry itself, with its humdrum and its inertia. To one and another plain man the country over, sections of this that Professor Bryant has gathered so laboriously, with much else that is just as important, is the most familiar of work-a-day fact, so much so that he may be tired of it. The majority of men engaged in logging would probably wonder, if they thought of it, what there can be in it to write a book about and why any one should want to do it.

That is a very contracted view, of course. To many indeed it seems clear that the industry must change, indeed that it is changing. Operations in some sections are being conducted on a large scale; competition is increasing and traditional methods no longer suffice; the human side of the industry is shifting, while in the background lies the demand for adjustment between the interests of the community and those of the industry. All this indicates that somehow trained intelligence must more and more be applied to its conduct.

That process is indeed taking place now in natural ways (there are numerous means of training); but some have for a considerable time been looking to the Forest Schools for leadership. Up to this time, it may fairly be said, there has been a good deal of disappointment. Professor Bryant's book, assembling and organizing information, attracting men to the work by showing what is in it, informing those whose relations to it may be indirect but telling, is perhaps the beginning of more effective dealing with the opportunity.

One feels, however, like putting in a word of caution. That arises in part from the limitations of literary work before mentioned; in part also from the fact that knowing how a thing may be done is by no means the same as ability to effectively do it. Various classes of men, therefore, may profit by a perusal of "Logging," but no young man should think that because he has studied it he is by reason of that a competent logger. There is too much of the art that the book does not contain; then the successful logger is a man who has himself been thoroughly tried and sifted. That employment of the book, however, is hardly intended by the author, and the error is one not likely to be fallen into by those who come under his direct instruction.

AUSTIN CARY.

U. S. FOREST SERVICE,
WASHINGTON, D. C.

THE LUMBER INDUSTRY[1]

Not many readers of the Proceedings perhaps know of the Alexander Hamilton Institute, which is an institution in New York giving high-grade business courses through correspondence. For this course Mr. Kellogg has prepared a lecture on the Lumber Industry, which is an attractive pamphlet of 104 pages.

With his history, Mr. Kellogg could not, of course, omit referring to the broad interests subserved by forest growth. This he does in his first chapter, which is followed by others, giving the statistics of the lumber cut of the country and a brief statement of amount and kind of the country's timber resources. But the main portion of the work, in harmony with the purpose of the course into which it fits, is devoted to the commercial aspects of the industry itself. He tells of the different ways in which a lumber operator may stock his mill, including the purchase of National Forest stumpage; describes the operations of lumbering briefly under the heads of logging, log transportation, manufacture, and marketing, while nearly a third of the work is devoted to a discussion of cost keeping, with illustrations of forms and methods employed. In conclusion, he has a little matter descriptive of lumber manufacturers' associations and their work, and a brief, meaty chapter on "tendencies in the industry," dealing with large *versus* small mills, economies in production, and better utilization.

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[1] By R. S. Kellogg. Alexander Hamilton Institute, New York.

It seems as if a person unfamiliar with it ought to get through this pamphlet quite a clear and balanced idea of the lumber industry as it exists, although that must perforce be elementary. The plan of treatment seems capable of expansion.

AUSTIN CARY.

U. S. FOREST SERVICE,
WASHINGTON, D. C.

TRAITÉ D'ENTOMOLOGIE FORESTIÈRE A L'USAGE DES FORESTIERS, DES REBOISEURS ET DES PROPRIÉTAIRS DE BOIS[1]

As Professor Henry correctly states in his preface, "Forest entomology is the most important branch of forest protection." Until the appearance of this volume, France lacked a comprehensive work on forest insects commensurate with modern requirements of forest protection. His thorough training in German and Swiss forestry schools, coupled with considerable practical experience as a forester and a bent for observation on insect life, evidently well fitted M. Barbey for the task.

As indicated in the title of the work, the author aimed to make it a handbook or guide to the forester, manager, or owner of natural or planted forest. As a practical forester himself, he recognized the importance of classifying the insects in accordance with the trees they infest, rather than the systematic position of the insects in nature, thus at once adapting the work to the purpose intended.

The introduction is followed by an explanation of the method of grouping the insects and the reasons for pursuing it. A brief history of forest entomology is then followed by a concise study of the morphology and systematic position of forest insects. Then the trees are treated, by dwelling on each insect of more or less pronounced economic importance affecting definite portions of them. Thus insects affecting roots, trunk and branches, wood, twigs, buds, leaves, and fruit of a spruce, fir, pine, larch, oak, beech, chestnut, birch, poplar, linden, elm, maple, ash, hornbeam, alder, willow, hornbeam and service berry, and acacias are dwelt on in the order named. The scientific name of each insect, the order and family to which it belongs, as well as the most common synonyms and the common name, are given. Those of us who have had the task of placing an insect systematically will appreciate the advantages of these apparently minor details. Judging by the index, 616 species of insects were found of sufficient importance to be included in the work. As some of the insects attack more than one species of tree, repetition is avoided by cross-reference. In each instance the morphology and biological relations are followed briefly by methods of prevention and control. Useful forest insects are barely touched on in a special chapter. An extensive bibliography and full index close the volume. The author makes good use of all available literature, supplementing it here and there with original observations.

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[1] By A. Barbey, with preface by Henry, Vice Director and Professor at the Ecole Nationale des Eaux et Forêts at Nancy. 624 pp.; 6°; 350 text figs.; 8 colored plates. Paris. 1913.

The work excels in the illustrations of insect work. Probably because of the mission of the book, the author evidently laid most emphasis on this portion of the illustrations. The colored plates are also highly satisfactory. Practically all the illustrations are original and the reproduction is highly meritorious. Taking it all in all, the work is a welcome addition to the rapidly growing literature on forest entomology that is very helpful to the specialist as well as the layman.

In his conclusions the author has the following to say regarding the United States:

"In the United States they are actually at war with the injury incurred to fruit and forest trees by *Liparis dispar* and *L. chrysorrhœa.* They have also created on the other side of the ocean a vast service of applied entomology which has the task of studying the various manifestations of the life of injurious insects, and more particularly to ascertain the distribution and propagation of the parasites of injurious insects. Up to the pesent, the first experiments attempted were apparently crowned with success, and there is good chance that this new form of forest protection will be extended; it is to be hoped that old Europe will in its turn undertake experiments of this kind."

Finally, the author says:

"By way of résumé, the extension of insect invasions depends altogether in the first place on meteorologic conditions, then upon the nature of stands, their composition, their state of conservation, and finally upon the vigilance of the forestry personnel, superior and subordinate. The more the latter knows the life of Xylophagids, the more efficacious will its intervention become."

JACOB KOTINSKY.

U. S. BUREAU OF ENTOMOLOGY,
WASHINGTON, D. C.

PROCEEDINGS OF THE SOCIETY OF AMERICAN FORESTERS

Copies of the Proceedings may be obtained from the Secretary for 50 cents each number.

Volume I, Nos. 1, 2, and 3, 1905 and 1906. 189 pages.

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The Proceedings of the Society of American Foresters appears quarterly—in January, April, July, and October. It contains papers delivered before the Society at its regular meetings, and original contributions by both members and non-members of the Society.

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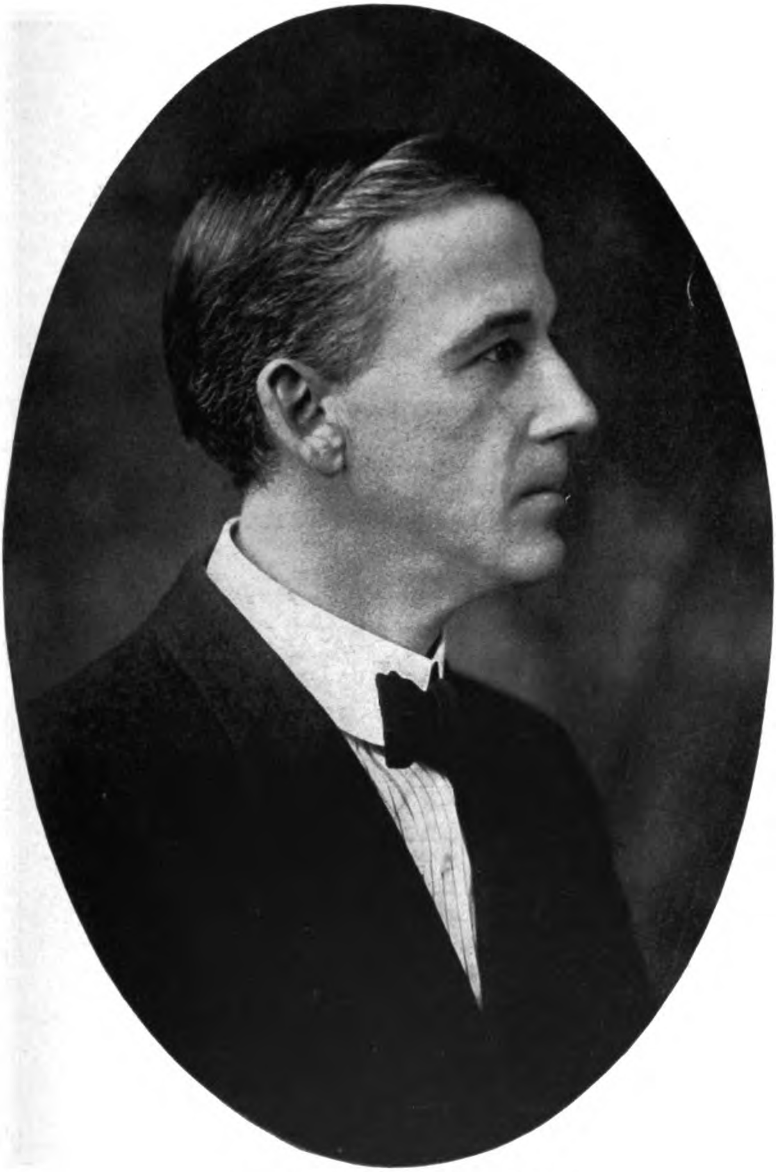

OVERTON WESTFELDT PRICE
1873-1914

Overton Westfeldt Price

The sudden and untimely death in North Carolina, on June 11, of Overton W. Price, one of the founders of the Society of American Foresters, and for five years its Vice-President, brought a profound shock to his fellow-members in the Society and to all those connected with the conservation movement in this country. Born in 1873, in England, and receiving his earlier education at the Episcopal High School, Alexandria, and the University of Virginia, Mr. Price later studied forestry in Europe and on the Biltmore Estate, North Carolina. In 1899 he entered the then Bureau of Forestry as agent, being promoted the following year to Superintendent of Working Plans and in 1901 to Associate Forester, in which position he served with conspicuous success for nine years. On leaving the Forest Service in 1910 he became Treasurer and later Vice-President of the National Conservation Association. Besides the latter office, he held at the time of his death the position of Consulting Forester to the Government of British Columbia and that of representative of the estate of the late George W. Vanderbilt in forestry matters. He was the author of a number of reports and articles on forestry, and also of "The Land We Live In," a boys' book of conservation which has reached a wide audience. In addition to the Society of American Foresters and the National Conservation Association, Mr. Price was a member of the American Forestry Association, the National Geographic Society, the Sierra Club, the American Fisheries Society, and the Cosmos Club of Washington.

At a special executive meeting held on June 17 the following resolution was adopted by the Society regarding Mr. Price's death:

By the death of Overton Westfeldt Price the Society of American Foresters has lost one of its most distinguished members, and the profession of forestry in this country one of its founders.

From the first he assumed a foremost place in his profession, bringing to the solution of pioneer technical problems a degree of originality and insight which won him instant recognition. As Associate Forester of the Forest Service he shaped in large measure the present organization and policies of the Government in forest work.

As Secretary of the National Conservation League, and later as Vice-President of the National Conservation Association, he was a fearless leader in the nation-wide movement for the conservation of natural resources. The recognition of his attainments as a professional forester in the broadest sense caused his counsel to be sought by nations other than his own.

As an author and educator his influence upon the thought of the public in all that relates to the wise use of natural resources has been and must continue to be far-reaching.

His deep sympathies, his broad vision, his enthusiasm, and his readiness in every way to aid and encourage those with whom he came in contact were qualities by which he strongly influenced the lives of many men; while his never-failing comradeship, his contagious spirit of youth, and his strong and hopeful outlook upon life endeared him to every man who was privileged to call him friend.

His memory will live in the profession as that of one in whom were embodied in a high degree the ideals of the American forester.

TO REMEMBER
LOUIS MARGOLIN
WHO LOST HIS LIFE NEAR THIS SPOT
JUNE 20, 1914
IN THE LINE OF DUTY
(BY HIS FRIENDS IN THE SERVICE)

Louis Margolin

The death of Louis Margolin removes an able and promising forester from the ranks of the Society. Mr. Margolin had charge of timber reconnaissance on the National Forests of California and was inspecting one of the projects in the Sierras between the North and Middle Forks of Kings River. It is probable that on June 20 he slipped from a foot log in crossing Dinkey Creek, which was swollen by a heavy storm, and was drowned.

Margolin was born in Russia in 1880. His earlier education was obtained in the public schools of New York City and at Cooper's Institute. He received his technical training in forestry at Cornell University; and also spent one year at the Lawrence Scientific School of Harvard University.

He entered the Forest Service in 1905 and served until his death, with the exception of about one and a half years spent in cruising British Columbia timber in the employ of a Canadian forest engineering firm.

Margolin was a forester of unusual mental keenness. He was exceptionally well-grounded in silvics and mensuration, and did much original thinking in these subjects. His professional work was largely on the investigative side of forestry, including timber estimates and forest mensuration. He has contributed in no small degree to the permanent upbuilding of these phases of American forestry. Probably his most important and distinctive work was the study of eucalyptus culture in Hawaii and of the yield from eucalyptus in California. Bulletins embodying the results of these studies were published by the Hawaiian Board of Agriculture and the California State Board of Forestry.

The inscription at the top of this page will appear on a bronze tablet to be erected by Margolin's associates in the Forest Service at Ross Crossing, where he met his death.

At a special executive meeting held on July 29 the Society of American Foresters adopted the following resolution in reference to Margolin's death:

The Society of American Foresters expresses its profound regret over the death of Louis Margolin, for eight years one of its active members.

His loss removes an American forester of high attainments, who has contributed in no small degree by sound research and vigorous thought to the permanent development of the science of forestry.

As a worker of exceptional mental power, high ideals, and untiring industry, he made his years of professional service exceptionally fruitful, and has left a permanent imprint upon scientific methods in the special phases of forestry to which his efforts were devoted.

As a member of the public service, he discharged efficiently and faithfully the responsibilities entrusted to him without regard to personal acrifices or danger.

In his death the Society of American Foresters loses a loyal member of promise in his profession and of proven capacity for effective service.

Proceedings
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VOL. IX JULY 1914 No. 3

PLAN FOR BETTER MANAGEMENT OF FARM WOODLOTS

BY J. H. FOSTER

Delivered before the Society April 2, 1914

When one comes to realize how little attention is given to woodlots by their owners, how much literature has been distributed, and how many lectures delivered by foresters during the last 10 or 15 years, one is inclined to be discouraged in any efforts to introduce forestry practices among woodlot owners. It is well to pause occasionally and examine this situation and the apparent failure to solve the problem. The woodlots are valuable. They are worth improving and treating rationally. The owners in general recognize their value, whether the lots are mature or only partly mature. But when the timber is marketable, they proceed to cut it without much thought of asking a forester for advice or of determining for themselves how the work should be handled in order to give them the best returns, and at the same time give due consideration to the future growth.

Have the efforts of foresters been productive of any results in woodlot management? If not, what is the reason for this seeming indifference? How can we encourage better management of farm woodlots? These are real and vital questions relating to a very important field of forestry work.

In answer to the first two questions, I would say that forestry has advanced just as far and in precisely the directions that foresters have been most efficient in presenting the subject to the owners of woodlots. Fire protection has made wonderful advances. Scarcely a fire is permitted to burn unchallenged nowadays. You may say the wardens look after the fires. That is true; but, fire wardens or no fire wardens, the farmers and residents of most woodlot sections are usually on the ground and are fighting the fires. There has been developed a sense of town pride and neighborly co-operation which prompt people to leave their work and fight fires which occur in their vicinity. And it is not because these people expect to be paid for fire-fighting that their services are given so freely.

There has been a notable development of interest in forest planting. There are more inquiries made of foresters regarding planting than along any other line of technical forestry work. Many of these inquiries are from summer residents and people of means who do not know for just what purpose they are planting; but still many others are from hard-working farmers who wish to improve the value of their property.

There is a great deal of interest in improving young stands of pine by cleaning out gray birch and hardwoods in mixture. The gypsy-moth scare has been responsible for much of this in New Hampshire and Massachusetts. The importance of removing oak and gray birch from pine stands has spread like wildfire among the woodlot owners. There are 100 inquiries regarding this phase of the woodlot problem to one regarding thinning or the means of securing pine reproduction after cutting. There has been more systematic and extended effort to educate woodlot owners to the gypsy-moth danger than to any other connected with the woodlot. There has developed a very gratifying response. The three features of woodlot forestry—fire protection, planting, and clearing pine stands of hardwoods as a protection from gypsy moth—have advanced farthest, and are the most common topics of forestry conversation and discussion wherever farmers gather together. This is clearly shown at the farmers' short course meetings at the State College at Durham, N. H., every January, and wherever lectures are given in forestry at the granges about the State. These three features of woodlot forestry have been most persistently presented in one way or another to the woodlot owner, and he is interested in them. Therefore it seems to be unquestionable that the efforts of foresters have been productive of results in these directions.

The reason for the seeming indifference to woodlot management, so far as it relates to systematic cutting and efforts to secure good reproduction, is either that foresters are not reaching the woodlot owners at all on these questions, or else they are not reaching them with information that is convincing. I have particularly specified systematic cutting and reproduction, because this is a very important—probably the most important—feature of woodlot management, and certainly one in which foresters have made but little progress. The statement also applies to thinning young stands for accelerated growth. Woodlot owners do not practice it; yet many will prune off side branches of pines, and are convinced that it either increases the growth or improves the quality. Most farmers have never thought about thinning. Some do not believe in it. Here, again, foresters either have not reached the farmers at all, or else their statements have carried no weight. The average farmer wants to be shown. Even if he takes the time to read, he cannot be convinced by mere silvicultural statements in a forestry bulletin.

In reply to the third of the above questions, "How can we encourage better management of farm woodlots?" the answer, according to my best judgment, is to establish a more personal and intimate relationship with woodlot owners in each town. This can be done only by systematic demonstration and persistent co-operation by foresters who are willing and *able* to know the practical side of woodlot operations and the marketing of the products of woodlots. Having won the confidence of woodlot owners, the forester can advance ideas as to management which owners would otherwise dismiss without consideration.

In considering how foresters can establish a more personal and intimate relationship with woodlot owners, it may be advisable first to indicate what are some of the factors entering into the present situation. So far as this article is concerned, woodlot owners may be divided into two classes: (*a*) non-residents who know very little about the condition of their lots or the values of standing timber, and (*b*) farmers and resident owners owning lots which are parts of their establishments who know more or less about timber values and conditions in their lots, but who know very little about handling the lots from the market and the silvicultural points of view. Owners other than the ones in these classes are presumably owners of country estates, speculators, or timber buyers whom this article is not intended to consider.

Both of the two classes above mentioned are the victims of parasitic middlemen who pick up lots and sell the timber on them to portable millmen, or else job out the logging, sawing, and hauling, and make a neat profit for their trouble. The non-resident is the more likely victim. This middleman usually sells the cut-over land sooner or later for what he can get. He is not a producer, and he robs the former owner of his legitimate profit. This middleman—or timber buyer, as he is commonly known—works in much the same way as the agricultural middleman or buyer who pays little to the farmer and sells to the wholesaler at a profit which rightfully belongs to the farmer producer. The woodlot middleman usually plies his trade on the side. In addition to buying and selling timber, he is a merchant in town, stable keeper, lawyer, or one who always has some cash on hand and picks up a dollar here and there wherever he can. He is generally sharp on a trade, and is well acquainted with his community. There is no place for this man in woodlot management. Foresters can make his business unprofitable by coming in close personal touch with woodlot owners and giving them information of real practical value.

The lumbermen or millmen buy lots and standing timber directly from the woodlot owners in the same manner. This is also true of lumber and box companies, which may own and operate several scattered mills. While the woodlot owner needs to be instructed regarding the values of standing timber and protected in a measure against these lumbermen and millmen, no criticism is aimed at the real lumberman or millman who buys as cheaply as possible. He does the actual work, takes the chances of profit or loss, and has an investment in mill and equipment. In many cases teams and men are constantly employed. He is a manufacturer, and has a legitimate place in the management of woodlots, as long as the woodlot owner is intelligently prepared to engage in business with him.

There has been a great awakening of interest in forestry as a result of propaganda and the distribution of forestry literature. Everywhere it is proclaimed by the press, and people have come to believe in forestry without knowing in a tangible way just what it means. It is only fair to say that this widespread interest has done a great deal of good. It has given us laws, Federal and State forests, appropriations, an interest in planting, and has opened up a field of labor for foresters. Nonresidents and well-to-do people with money to spend have carried on some silvicultural work as a result. Large audiences of women's club members, grangers, members of city boards of trade, and business men's associations have been enlightened and entertained, but this does not help the farmer to apply the information to his woodlot. I believe that at least 75 per cent of the people who attend forestry lectures and read forestry literature have only very remotely anything to do with woodlots. As a matter of fact, most of the people who have shown an interest live in the town or city. The truth is that platform forestry does not reach a very large per cent of woodlot owners. The grange is a remarkable organization of people and the most extensive medium for reaching woodlot owners through lectures, but the average grange meeting is a social gathering at which the farmers and woodlot owners are either absent or are too sleepy and tired to pay attention to the lecture. The farmers' institute meetings are widely advertised, but of only annual occurrence in a few places in each State. They are generally well attended, but scarcely reach a large number of woodlot owners. The forestry exhibits at the State and county fairs help to extend the knowledge of forestry in a general but more or less superficial way. This is also true of the lectures given at the agricultural colleges during the so-called "farmers' short course" which nearly every State college now gives each winter. At New Hampshire College the attendance at the forestry lectures during "farmers' week" has increased in a very interesting manner each of the past three years. The most significant indication of increasing interest is the fact that this winter 75 people tramped through snow a foot deep with their Sunday clothes on in order to be shown some different methods of cutting pine lots and improvement work in young growth. Two years ago, when the walking was good, scarcely a dozen were interested enough to take the tramp. Enthusiastic as we may sometimes become when increasing attendance and interest are shown at lectures and meetings, if the situation is carefully analyzed the truth comes out that the people who show the interest and give their time in attendance are in a large measure enthusiastic bystanders on the side lines, and not those who are in a position to demonstrate to others by practical work on their own lots.

The forester who can reach the ordinary woodlot owner in a manner that is worth while must go to the woodlot with him, and the owner must be impressed with the forester's superior knowledge of handling and marketing woodlots as well as his intimate acquaintance with conditions and means of improving them. Then the forester must follow up the advantage gained by actually helping the owner to carry out the recommendations prescribed.

The average woodlot owner is ready to practice forestry in more than half the cases. The value of white pine is well appreciated among the farmers. It is no longer necessary to talk to them about cutting low stumps and utilizing material in the tops to avoid waste. They are constantly asking how they can save the pine from the gypsy moth, and are willing to cut out oak and hardwood to save or benefit the stand. Frequently they spend odd hours pruning the side branches in pine stands. They are not thinning young stands or leaving seed trees or cutting lots by the shelterwood system, not so much because they do not believe in these things or because they have not heard about them, but because they have not been shown on the ground what such cuttings would be like, how much the sacrifice in actual quantity of merchantable timber would be, and what results should be expected. They have advanced as far as practicable measures have been presented to them clearly. In spite of all the literature and lectures, the average farmer does not distinguish between pruning and thinning, and does not know how to secure pine reproduction following cutting. He does not read much and attends few lectures. He is willing to be shown on the ground, and when he sees the forester's point of view is willing to give it consideration.

Any agricultural extension worker will tell you the same thing about advancing an interest in his particular field. The agricultural colleges and experiment stations were marking time so far as improving agricultural conditions on the farms was concerned until they began systematic extension work, which is now receiving such widespread consideration. For years the Department of Agriculture and the experiment stations in each State have been studying farm problems and distributing broadcast the results of their findings. It remained for them to discover in comparatively recent years that the way to reach the farmer and bring about results in farm management was to meet the farmer on his own land. Since then the Office of Farm Management of the Department of Agriculture has become a potent factor in agricultural development, and extension departments in 43 agricultural colleges have been reaching farmers in the most remote parts of the States. Appropriations of $50,000, and even $135,000, are made annually by some States, and the others provide more or less substantially for these extension departments, where efforts are directed toward carrying the knowledge gained through these years of study and investigation out to the farmers. In 27 States special forces of extension workers are employed who spend their entire time in the field. In other States the workers divide their time between the field, the college, and the experiment station. The Office of Farm Management at Washington is rendering real service to the farmers through agents located in different sections of the country and by co-operating with the States for the same purpose.

Very recently extension work has taken a still more decisive step forward by means of the so-called county agents. The agricultural colleges and the Office of Farm Management co-operate with counties in different States to bring the information of the agricultural colleges, experiment stations, and the National Department of Agriculture to the specific farmer who needs it. The agricultural colleges usually pay the salary of the county agent or adviser, and money is raised by subscriptions in the county to pay his traveling expenses about the county. The Office of Farm Management makes him practically a collaborator, gives him the franking privilege, and aids him directly with its counsel and advice. These advisers are young men trained in agriculture and with some practical experience in agricultural work, and they are placed in counties which are willing to contribute for their maintenance. There are upwards of 800 counties in the United States now having advisers, and the number is being increased as rapidly as funds can be obtained. In New Hampshire there are two county advisers, and there are eight in the State of Vermont. All of them are graduates of State agricultural colleges.

The duty of the adviser is to come closely in contact with the farmers of his county, acquaint himself with their conditions and problems, and use all the machinery at his command to aid them in improving their farms. He becomes the field agent of the agricultural forces of the State and nation. Those who have not followed this development closely would be surprised to see how far-reaching the movement really is, what results are being obtained, and what possibilities the future holds.

The Lever bill, recently passed by Congress and now awaiting final confirmation, is the latest step toward greater co-operative agricultural extension in the different States. This bill provides for an appropriation to each State agricultural college at present receiving the benefits of the Morrill Act of 1862, for the purpose of giving instruction and practical demonstration in agriculture and home economics to persons not attending or resident in these colleges, and imparting to such persons information through field demonstrations, publications, and otherwise, to be carried on in such manner as the Secretary of Agriculture and the State agricultural college may mutually agree. The bill provides for an appropriation the first year of $480,000 on the basis of $10,000 to each State agricultural college. This amount is to be increased by $300,000 each year following for nine years, after which $3,000,000 annually will be available. The amount which may be obtained by each State college over and above $10,000 depends upon a duplication by the State for the same purpose, and is limited by the proportion which the rural population of each State bears to the total rural population of all the States. According to the further terms of this bill, not over 5 per cent of each annual appropriation shall be applied to the printing and distribution of publications. Undoubtedly a new office will be created in Washington to supervise the carrying out of this measure. This bill if passed, will make possible an immense development in agricultural extension work, and it is presumable that the greater part of the funds will be used for work of the nature now carried on by county agents.

It would be of little importance to foresters to consider these statements relative to agricultural development unless they have a bearing on the problem of how to encourage better management of farm woodlots. There are, however, very material reasons why foresters should be interested in them. In the first place, they show rather conclusively that the promotion of agricultural development is along lines which foresters cannot but see must be taken in woodlot management if satisfactory progress is ever to be made. Furthermore, it does not seem unreasonable that woodlot management should be given a place in this great movement to reach the farmer, and it is not unreasonable that it should receive some of the funds which are becoming increasingly available each year.

I believe the county agents can be made an important factor in bringing about better woodlot management. It is true that most of these men at present have had no special training in forestry. They are, however, almost without exception graduates of agricultural colleges, and most agricultural colleges now offer courses in forestry. One of the two county agents in New Hampshire, and until recently both of them, were men graduated from the State college, and had taken one or more forestry courses. They have already rendered much assistance to woodlot owners in their respective counties. At New Hampshire College and in some other State colleges all students in the agricultural division are required to take one course in forestry. Some students elect other courses in addition. Students preparing for county work should be encouraged to elect as much forestry work as their time will permit, and instruction in forestry should be along lines which will be particularly useful to them as county advisers.

The time is coming when the agricultural county adviser will become a recognized force in every section of our country. No other person can become so well acquainted with woodlot owners, woodlot conditions, and the best methods of cutting and marketing the timber. Once they appreciate the importance of the woodlot and the responsibility of encouraging woodlot management as a part of farm management, they will soon become informed on forestry matters which concern them.

It seems to me there should be more co-operation between the Forest Service and other bureaus of the Department of Agriculture and with the States and the woodlot owners on this question of better management of farm woodlots. The abandonment by the Forest Service of the policy of making woodlot examinations was fully warranted. This kind of work should be done by men in the States who are familiar with local conditions. Unfortunately, however, most of the States do not have foresters enough in their employ to enable them to make any large number of woodlot examinations. The State foresters and their assistants make as many examinations as their limited time will permit. If they were to encourage woodlot owners to apply for examinations, their files would very soon be flooded with applications and they could not take care of them. It will be many years before State foresters in any State will be given appropriations large enough so that a sufficient number of trained assistants may be kept in the field to aid private owners of forest lands. The average farmer cannot afford, or at least is not willing at the present time, to pay for the services of a consulting forester. He is generally willing to pay the expenses of travel, and it may be better that he should pay something for the examination, provided the amount is nominal.

If the woodlot is in any sense a part of the general farm—and agriculturists as well as foresters will concede this—then I see no reason why woodlot management should not be considered with farm management and why the Forest Service should not co-operate with the Office of Farm Management or whatever other bureau or office may in the near future be established in the Department of Agriculture as a medium for reaching the private owner. If a large force of trained men is to be employed at Government expense in different counties to help farmers improve their farms, certainly it is not unreasonable that these trained men should consider the farmers' woodlots. The question as to how this co-operation can assume a tangible form is one which the Society of American Foresters might well consider. It has been my observation that the Office of Farm Management of the Department of Agriculture does not in any way consider the management of woodlots, although it does consider the management of every other branch of agriculture, drawing upon the different divisions for information. Woodlot values are often quoted, however, in connection with various other farm values. In many examples of farm accounting presented by agents of this office the woodlot has furnished so much revenue that an otherwise unprofitable farm has been shown to have a surplus instead of a deficit at the end of the year. The farm management expert should give the management of the woodlot proportionate consideration in his discussions and lectures.

Another field into which woodlot forestry should be permitted to enter on an equal footing with other branches of agriculture is the experimental work carried on by the State experiment stations under the supervision of the Office of Experiment Stations of the Department of Agriculture. Under the Hatch Act of 1887 and the Adams Act of 1906 the sum of $30,000 per year is now available for agricultural experimental work in each State, including the publication of results. While most State forestry departments may carry on experimental forestry work, if they choose, and some States, notably Ohio and Connecticut, provide special funds through their experiment stations for forest investigations, Hatch and Adams fund money is not used for this purpose. There is need of a large amount of investigational work in woodlot forestry, as any forester will admit, and the Hatch and Adams funds of the various experiment stations should be available for such work. The fact is that no systematic efforts have ever been made to bring this about.

Objections have been raised by experiment station officials in Washington to the use of Hatch funds on the grounds that forestry experiments required too long a time for completion or else were in the nature of demonstration rather than experimentation.

I believe that every State experiment station should have a forester on its staff. At the present time there are 15 stations which do have them, and several of those are in the prairie States. In States where little advance has been made in forestry, as in the South, a station forester might be the means of making advancement possible. Where a State college and experiment station are in the same place, as they are in most States, and a forester is employed in the college, there is no reason why he should not also be a member of the station staff.

The station forester who has teaching as a part of his duty is even less able than the State forester to spend much time with the owners in their woodlots. Better management of woodlots, if it is to be brought about, must be accomplished through the broad field of general farm management, in which so many forces are being assembled today. The various divisions of the Department of Agriculture must work together and with the State colleges of agriculture and the experiment stations along lines of extension and demonstration in order to reach the farmer and improve his woodlot. In the past this would have been impossible. With the recent development of agricultural extension in a very practical way and with funds for the purpose becoming larger each year the outlook for the future in this direction is indeed hopeful.

In conclusion, we must not lose sight of the fact that it is practical information that the woodlot owner desires. When a forester or adviser can tell him how much timber his lot contains, the costs of logging and hauling, who will do the sawing and at what cost, into what material the logs should be sawed, who are the most reliable purchasers of his lumber, what will be the freight charges, and then be able to answer a hundred other similar questions, the woodlot owner is pretty apt to see the virtue in a suggestion or two about providing for reproduction, saving the young timber on portions of the lot, disposing of slash, and possibly thinning out the young stand. Some of the woodlot publications recently issued contain information which will be of much value not only to woodlot owners, but to those who may be called upon to help forward the work of better woodlot management.

CO-OPERATIVE AND COMMUNITY MARKETING OF WOODLOT PRODUCTS

BY FREDERICK FRANKLIN MOON

Delivered before the Society April 2, 1914

My contribution toward the solution of the woodlot problem consists in advancing a single idea—one that is not new, perhaps, but yet may be original in this connection. I believe that in continuously urging an extensive campaign of reforestation and the establishment of communal plantations, the foresters of the United States are laying entirely too much stress on the production end of woodlot management. If the products can be marketed at a good profit, the farmer or small woodlot owner will look after the production himself.

My attention was first called to the importance of marketing the products of the woodlot when as a student in Yale I assisted the State Forester of Connecticut in valuing a woodlot for which the owner had been offered but $300 for all the timber. After marking the trees which were mature and estimating the quantity of lumber in each, Mr. Hawes decided that on account of the splendid size, quality, and proximity to market, the timber was worth $10 per thousand on the stump, or $1,000 for about 40 per cent of the stand. By sharp insistence and continued correspondence he finally prevailed upon the owner to stand out for this sum, which he finally received. As a consequence, the owner of that woodlot became one of the stanchest supporters of forestry in that section of the State because the practice of forestry in his case not only meant the improvement of the woodlot, with larger growth rate, etc., but also a large increase in the financial yield.

In making the following statement it should be understood that no hostile criticism is intended, because in most cases the foresters were doing all they had time to do, but the fact nevertheless remains that in the past, when silvicultural advice and protective recommendations were given by representatives from the various State foresters' offices and the Forest Service in Washington, the advisers were doing only half their job. In most cases, after a cutting was made according to their working plan, the proceeds were usually disappointingly poor through bad marketing, and it seems to me that in any plan of private co-operation to be carried on by the State to interest the private owners, the place for the

State or Federal Forest Service to assist is not at the production, but at the selling end. Why erect new factories (woodlots), when there are thousands of factories already in existence running on half time. Make the business profitable, and the factories can and will be run to full capacity by their present owners. If the owner of a 10-acre woodlot can be assured of a square deal, good prices, and a fair measure of profit, he is apt to regard forestry as a good business.

PRESENT STANDING OF WOODLOT MARKETING

The farm woodlot in the past has suffered chiefly from the wrong point of view. Ordinarily it occupies a portion of the farm of little value from the standpoint of agriculture; it has grown without assistance from the owner, and consequently the timber upon it is regarded as so much "velvet," and will be sold at a very low price, as a rule, to the first millman who offers real money. This situation has necessarily resulted in a low valuation being put upon the woodlot. The timber in most cases is sold without seeking a market, to some local individual who makes a business of buying stumpage either for speculation or to be cut at a portable mill. If we can succeed in enhancing the value set upon the stumpage of one or two woodlots in every locality by enabling the owners to market the timber growing upon them at a good profit, we will be doing advanced missionary work that cannot help accomplishing enormous good. We must keep our eyes on the financial as well as the silvicultural end of forest management.

All of us who have done any extension or co-operative work in the East realize what a hopeless problem it is for the average small woodlot owner to find a market for a limited amount of stumpage. Had he 500,000 or 1,000,000 board feet of any one species, the problem would be much simpler; but to market 10,000 board feet of ash, 40,000 of basswood, and say 100,000 each of beech and maple, at a decent price, requires rare skill in selling one's wares. The small owner needs our help. Therefore, in preaching co-operative marketing it is my belief we are approaching the problem from the proper angle.

Even if the owner can find some millman in the neighborhood to buy the stumpage, we all know that the price he receives is ridiculously low in most cases, and allows for excessive profit on the part of the purchaser. One instance comes to my mind in this connection of a man who sold a woodlot containing 180 acres for $900. The tract was located five miles from a college town in Massachusetts. The mill operator who bought the tract was a progressive lumberman, and made a rather heavy thinning, taking out weed trees, suppressed and diseased specimens. Within six months he had received the equivalent of $1,750 net, and still had the land and about 50 per cent of the growing stock. In other words, the purchaser made a profit of over 200 per cent, with the result that the original owner and his neighbors regard the successful marketing of woodlot products as a specialized business which they cannot attempt.

How are we to assist the producer in marketing his forest products with the greatest profit? It seems to me that the solution of this problem lies along the following lines:

1. A system of co-operative marketing where aid is given to the private owner from a central bureau, or
2. A community market which may assume one or two forms, either
   (*a*) A township wood market, feasible in such States as Connecticut, Massachusetts, etc. (Co-operative marketing under agent of county farm bureau.)
   (*b*) A subsidized millman who will receive support from a State Forester in return for square dealing and liberal prices for stumpage.

First. My suggestion in this connection is that a central system working toward the marketing of forest products should be inaugurated in each State having a central forestry bureau, whether State Forester's office or State College of Forestry.

It should be a portion of the duty of this central office to get information concerning uses and values that will enable the small owner to market his timber directly, and, furthermore, at the time advice on silvicultural management is given a "marketing plan" should also be made and a follow-up system be instituted to see that such a plan is carried out. Much literature has been disseminated concerning the various methods in which a woodlot could be thinned, of the evils of grazing, of the damage inflicted by fire, but very little help has so far been given by any institution or agency in the United States concerning the profitable marketing of the forest crop.

Another point that should be dwelt upon most specifically by this central bureau is to insist that all timber should be sawed to bill, if possible. We all realize that the average portable millman is apt to saw blindly, and, according to local practice, with very little regard to market needs outside of the immediate vicinity. As a result, the owner may have on his hands many thousand board feet of timber of good species sawed in the wrong dimensions for profitable marketing.

The New York State College of Forestry has already taken steps in the direction outlined above. In co-operation with the Federal Forest

Service we have published a report on the wood-using industries of New York State, which gives prices, quantities, uses of the various timbers, and the names and addresses of firms using the various species. This in the hands of a technical forester, or a man with better than the average intellect, is capable of being put to splendid use, but I am afraid that the average woodlot owner would have a difficult time in finding a market for his 50,000 board feet of basswood by means of such a report. (It might be said in passing that these bulletins, while published in splendid shape and containing an enormous amount of good information, are in rather poor form for popular use. They could be made much more useful to the average woodlot owner if each lumber concern or manufacturer were given a number, and then, under the tabular list of uses to which each species is put, the numbers of the various firms consuming the species and manufacturing the various articles could be appended. This would enable a man owning even a carload of any species to locate at once the number and then address of the consumer nearest to his locality and permit him to get in touch quite readily with him.)

In time it is our ambition to have the New York State College of Forestry a clearing-house for information on marketing by building up a card catalog system showing species, dimensions and amounts used, and prices paid by the different consumers of timber in the State, and if the owner of a woodlot in western New York writes to us and asks us where he can market his 25,000 board feet of ash, 75,000 of hemlock, and 100,000 of maple, we will be able to put him in touch with a manufacturer near by who will pay him a reasonable price for his material, provided it is sawed to bill.

Already we have started with several men who are cutting and marketing their woodlot products under our supervision. We are advising them concerning prices, markets, etc., trying to get them to sell direct to the consumer, and we are even going so far as to write the selling letter for them. (See specimen letter to Mr. C. J. Cummings, appended.) One of our men has received as high as $25 per thousand for his basswood in the log, a price which makes woodlot management seem worth while.

In addition, we are planning to make a State-wide reconnaissance of New York in order that later on factories can be advised concerning new supplies of raw material, and in addition that we may realize just what the timber possibilities of New York are.

The selling plan, as outlined above, can be put in force in any educational institution or in any State Forester's office. The extra machinery needed would probably be one man to devote his time to extension and co-operative marketing work and one stenographer to look after the correspondence. The entire service would be to the private owners, advising them concerning the protection, the cutting of and selling the proceeds of their forest property. In addition, any lecture work or reconnaissance that the same man could do would largely pay for his time. While we have not been working at this plan long enough to prove its complete success, I have not the slightest doubt concerning its practicability. In addition to the direct benefits, the idea strikes the average owner most favorably and the service given enlists wide public interest and support.

Second. Community Marketing.—The establishment of a community wood market I realize sounds highly idealistic, socialistic, and impracticable, but under present economic conditions I believe its execution to be fully as practicable in many localities as the communal woodlot. The idea seems workable, and is put forward in order that a discussion may be started, and if there is a germ of truth or practicability in the scheme to see whether or not your criticisms cannot bring forth a full-fledged plan. Many of us who have had experience in securing appropriations know how hard it is to get the city fathers or the town selectmen to appropriate money for a cause whose need is obvious, and which is demanded by a large number of influential citizens and voters; but when it comes to appropriating money for the benefit of the voters forty years hence, I believe it will be still more difficult. In scattered instances, where land and money may be given by some public individual who is both a nature lover and a philanthropist, communal woodlots may prove feasible.

In States like Massachusetts and Connecticut, where the town is the fundamental unit of the State, such a marketing scheme should not be difficult of execution. In practically every town in the New England States there is a man whose office is variously styled "tree warden" or "city forester," who is either appointed or serves *ex officio*. Already the Bay State, through the Massachusetts Forestry Association, has served notice that 150 technical men of this type will be needed. These men in Massachusetts are to be not only shade-tree experts, but also conversant with technical forestry, and to have charge of moth work and fire protection as well as shade-tree preservation. A man in such a position could not only advise silviculturally, but be of enormous assistance in securing markets for local forest products. By co-operating with adjoining town foresters, through the medium of the State Forester's office, all data on dimensions, prices, and specific needs could be made available for any producer or consumer in the State, to the end that new supplies of raw material would be uncovered for the manufacturer, good prices obtained for the producer, and no doubt close utilization and elimination of waste be achieved by finding uses for odds and ends.

In this connection, the plan of enlisting the services of the county agricultural advisers, as suggested by Dr. Knapp, seems extraordinarily rich in possibilities. There are nearly 800 of these men in different parts of the United States, each one with a thorough scientific training and many of them already familiar with at least the rudiments of forestry. Could these men be induced to interest themselves and their clients in the marketing of forest products, the woodlot problem would be much nearer a solution. They are urging co-operation and association buying and selling. Why not add forest products to their list of wares?

As a final suggestion, and perhaps a starting point in some communities where neither of the above plans could be used, the State Forester might secure a reliable sawmill man and throw work to him, with the understanding that it would be in return for reliable cutting and on the payment of a fair stumpage price to the owner. This, of course, would be but a step, but nevertheless might serve as a starting point for the ultimate idea of direct marketing.

While community marketing seems to be a perfectly feasible plan, it may not work in any given community in exactly the forms which has been described. However, we all realize that as a psychological measure the interest of the private owner in forestry could be much more readily stimulated by enlarging financial returns than by increasing production. Owners are continually asking at the present time, "How soon can we get returns, and what will the profits be?" Unless we can make forestry financially profitable, either now or in the immediate future, the extension of private forestry will be slow and limited largely to the estate owner and settled farmer.

Finally, it should be clearly understood that the extension to communal forests of the policy of extensive reforestation is not to be discarded. Both should be encouraged for silvicultural and economic purposes, but it is my firm belief that the production end has been overplayed by the foresters of the United States, and that the money, time, and energy invested will yield larger returns in promoting the forestry cause if applied toward better marketing of the forest crops.

APPENDIX

Sample Letter Written to Woodlot Owner

MARCH 24, 1914.

MR. C. J. CUMMINGS, *Tully, N. Y.*

MY DEAR MR. CUMMINGS: Your letter of March 21 received, and I am submitting herewith a suggestion concerning the marketing of basswood. The suggestion is that you write a personal letter, typewritten preferred, to each of the following manufacturers:

Automobiles	H. H. Franklin Automobile Co., Syracuse, N. Y.
	C. W. Moyer Automobile Co., Syracuse, N. Y.
Brooms	G. P. Bortel Co., broom manufacturers, Rochester, N. Y.
Cameras	Eastman Kodak Co., Rochester, N. Y.
Musical instruments	The Amphion Musical Instrument Co., Syracuse, N. Y.
	Thos. H. Knollin, manufacturing musical instruments, Syracuse, N. Y.
Toys	Wilkinson Manufacturing Co., Binghamton, N. Y.
	K. W. Scovill, Manlius, N. Y.
Trunks	Syracuse Trunk Works, Syracuse, N. Y.

stating the amount, quality, and size of your timber and asking them if they could use any of it. If you will permit me to suggest further a form letter, something like the following might be quite appropriate:

"GENTLEMEN: I have on hand at Tully, N. Y., about 70,000 board feet of prime basswood in the log, which I think is especially suitable to ——— (better insert here the particular instrument or product which they manufacture). The logs range from 12 to 16 feet in length and are anywhere from 3 to 4 feet in diameter. The quality of this basswood is unusually high, as at least 50 per cent will run clear. In case you are in the market for any basswood, I should be glad to know the sizes you wish, as I can saw the logs to bill. Awaiting your favor, I remain."

You will notice that I have selected firms out of the wood-using industries report which are located in and near Syracuse, so that in case you make a sale this year you would have a near-by market established for the future. I would be extremely glad to hear concerning the outcome of this venture, and trust you may succeed in selling your basswood at considerably above the average price for this State. You will notice on page 18 of the wood-industries report that $27.36 per thousand board feet is the average price. Your timber, however, on account of its size and high quality, should be worth considerably more.

Most sincerely,

——— ———,

Professor of Forest Engineering.

THE ADMINISTRATION OF A NATIONAL FOREST FOR NAVAL STORES

BY INMAN F. ELDREDGE

Delivered before the Society December 4, 1913

Since the Florida National Forest is unique among the National Forests of the United States, it is well to start this paper with a brief description of the Forest and its resources. Most people, when the State of Florida is mentioned, conjure up a picture of waving palm trees, alligators, orange groves, and Spanish moss, with the Everglades as a sombre background. This may be a correct impression of the extreme southern portion of the State, but Florida is nearly 1,000 miles long, and west Florida, particularly the extreme northwest, in which is located the Florida National Forest, differs so widely from the conventional idea of Florida that a first visit through the Forest is often very disappointing to the northern forester. Only in the length of its summers and in the excessive amount of its rainfall can the climate of the Florida Forest be considered truly subtropical, and its chief plants and animals are only those found throughout the Carolinas, Georgia, and southern Alabama.

The Forest is located in the counties of Walton and Santa Rosa, on the shores of Choctawhatchee Bay, Santa Rosa Sound, and East Bay, almost in the shape of a rectangle 60 miles long and 20 miles wide. It occupies a gently sloping and slightly rolling sandy plain, drained to the Gulf of Mexico through many streams, and is timbered from end to end for 99 per cent of its area. With the exception of long, narrow hardwood swamps along the streams, the entire Forest is composed of longleaf and Cuban pines, rather stunted in size and of great age, but remarkably sound and thrifty. The soil throughout the southern half of the Forest is almost a bottomless white, rather coarse sand, with a light mixture of humus only in the most favorable locations. In the northern half of the Forest a substrata of clay is found at a depth varying from five to twenty-five feet.

As a saw-timber proposition the Forest is most disappointing. Cutting according to approved Government practice, the stand does not yield an average greater than 1,200 feet per acre, being best in bottoms and valleys and poorest along the tops of the low sand ridges. The typical longleaf pine tree averages a little better than 11.60 inches d. b. h., with a merchantable height of 30 feet and a total height of 65.3 feet, with a full but often flattened crown. On account of its great age, the tree shows an unusually large percentage of heartwood, with a correspondingly thin layer of sapwood. The timber is deeply rooted in the sandy soil and is not liable to windfall, and, being heavily armored with bark, suffers but little damage from fires. Pine beetles and lightning are the greatest causes of loss in unboxed timber, although in the oldest trees heart rot is prevalent to a limited extent.

The chief asset of the Forest lies in its value for naval stores. As a producer of these valuable products, and as a field for studies and experiments in the technical and practical sides of management for naval stores, it is alone among the National Forests of the United States. The Forest is situated in the midst of the naval-stores belt, within 25 miles by water of the second largest naval-stores export port in the world. Because of the excessive rainfall and the deep, porous soil in which it is found, the longleaf and Cuban pine timber in the Florida Forest and this part of west Florida generally is noted among turpentine men for its producing qualities. The yield per acre, of course, is not as great as that obtained from the heavy stands that were once found in the Carolinas and Georgia, but tree for tree west Florida timber compares favorably with any in the Southeast. As is well known, particularly and ruefully so to turpentine men, the supply of unworked turpentine timber, or round timber, as it is known, is almost exhausted in the present naval-stores belt. Where a few years ago the supply of round timber seemed almost inexhaustible, now large tracts of uncupped timber are so scarce throughout the South Atlantic and Gulf States that their location is as well known as are the location of virgin white-pine forests in New England. The owners of virgin pine timber at the present time are exceedingly fortunate, for they have a commodity that is increasing in value with every season and increasing at a rate that is surprising to one not acquainted with all the circumstances of the industry. In the Florida Forest there is a body of a little less than 300 sections of virgin turpentine timber of good quality easily accessible to either railroad or water transportation. This body of timber is scattered "checker-board" fashion among the holdings of 26 different naval-stores companies, each with its extraction plant located within or near the Forest. All of the privately owned turpentine orchards have been worked for from 8 to 12 years, and with very few exceptions every one of them has cupped their last acre of virgin timber, and are consequently wholly dependent upon the Government for all future supplies of this necessary commodity.

It is patent that the Florida Forest should be managed primarily for the production of naval stores for the following reasons:

1. The timber is too small and the stand too scattered to be of great value for saw-timber purposes alone.
2. The timber is of excellent quality for production of naval stores.
3. It is one of the few remaining large bodies of virgin timber in the Southeast.
4. Owing to its location, it is accessible to railroad and boat lines of transportation to one of the main markets and to already existing and conveniently located turpentine stills.
5. There is a strong and competitive local demand for the timber that guarantees the receipt of full value for the product as well as a constantly increasing stumpage rate.
6. Because of its location and the immense demand for it, it is possible for the supervising forester to locate and regulate the annual cuts according to the best principles of forestry rather than at the demand of the purchaser, as is unfortunately the case in the timber sales in many of the Western Forests.

In this discussion the Ocala district of the Forest which is located in east Florida is not considered, since it has practically no value as a naval-stores proposition. The western division of the Forest is divided into four ranger districts, each in charge of a district ranger, with headquarters located with regard of the convenience of looking after turpentine permits as well as the consideration of near-by means of transportation and communication. The supervisory force consists of a supervisor and a forest assistant, with one clerk in the office. The Forest headquarters are located for eight months out of the year in the heart of the Forest, and is connected by telephone with not only the ranger stations, but with all of the turpentine operators and other users. In order to be in closer touch with operators during the time when turpentine permits are being advertised, contracts awarded, bonds executed, etc., the headquarters are moved to Pensacola during the winter months, for practically all the operators in the Forest do their buying, selling, and financial business through Pensacola naval-stores factors.

While looking after turpentine permits is the main duty of the field force, it is not the only one, and there is not any season throughout the year, winter or summer, in which field work is not being carried on. The construction of permanent improvements, such as roads, trails, bridges, telephone lines, buildings, fences, wharves, etc.; the administration of the grazing business, which in the Florida Forest is the largest of any of the Eastern Forests; the planting and sowing of maritime and longleaf pines, cork oak, camphor trees, juniper, etc.; intensive fire patrol during five months of the year, and the many small details of routine work, such as special uses, free uses, cordwood sales, timber sales, surveying, investigating trespasses, etc., etc., keep the entire force busy at all times.

From the time the contracts are executed each district ranger is made responsible for the turpentine permits in his district, always, of course, under the instructions and direction of the supervisor. All usual dealings with the permittee regarding the progress of a permit are taken up through the district ranger. The district idea is carried out to its fullest extent, both as regards the force itself and the public at large.

In June of each year the preparation of the annual turpentine report and budget for the next turpentine season is undertaken. The supervisor prepares to spend from two weeks to a month of field work in the personal inspection of areas and the discussion of terms, conditions, etc., with proposed applicants. Before starting on the trip he decides approximately on what sections he will put on the market for next year's cupping, and discusses the prospects with the district rangers and often changes them as improvements are suggested.

In locating the areas to be turpentined each year certain well established underlying principles are followed. Eleven locations, or, as they are called, "rides," have been established in the Forest, which serve as nuclei about which are gathered various turpentine permits. These rides are scattered more or less uniformly over the Forest, and are located with the idea of later serving as logging chances when the timber in them has been thoroughly worked out for naval stores and is ready for the saw. The fourteen crops of turpentine cups, which under the present working plan constitutes the yearly cut, are located in these constantly expanding units.

There are several advantages to be gained through this system of locating the annual cuts, in addition to the concentration of the future saw-timber areas. The cost of administration, inspection, cup placing, and fire protection is much reduced and the work rendered much more efficient; particularly is this true in the matter of fire protection. The Forest plan contemplates the absolute protection from fire of all areas after they have been turpentined and logged; this is necessary to assure natural reproduction. By the time that a ride has reached the logging period it has attained such size that it will be feasible to erect fire towers and employ fire guards in the furtherance of a system of intensive fire protection such as will be necessary to achieve any results in this fire-ridden country. In the event artificial regeneration is undertaken in the logged-over areas, the cost of the seeding and planting will be much reduced where the areas to be regenerated are concentrated into groups.

The various rides have been located in such a manner, with regard to the location of turpentine stills, drivable streams, means of transportation, etc., as to allow of competition between rival naval-stores companies in bidding for the various annual permits. It will be noted also that every ride is located either on drivable streams or near a railroad or near water transportation.

Eventually, of course, the various rides will merge one into the other; but by that time logging will have commenced at or near the center of each ride, and after it has started it will progress at the same rate and in the same direction as that now being taken by the turpentine permits, for the timber will come on the market for logging purposes automatically at the same rate and in the same locations as it is now being put on the market for turpentine purposes. From time to time policy and expediency have made it necessary to locate scattered permits which are not connected with any particular ride. These have been and will be kept at a minimum, however, and will cut a very small figure in the management of the Forest.

After the areas are chosen the supervisor and district ranger visit and inspect them and check the reconnaissance estimates. The whole ranger district is covered before any definite steps are taken to find applicants. When it has been fully decided as to what areas will be put on the market the matter of finding applicants is taken up either in person, over the telephone, or by correspondence. Operators who might reasonably be expected to bid on the timber are interviewed; prices, markets and values, terms, requirements, regulations, suggested improvements, etc., are discussed fully with turpentine operators, and no definite conclusions as to stumpage prices are reached until practically the whole Forest has been canvassed and conditions discussed.

The annual budget is then prepared by the supervisor. Each proposed permit is taken up in turn and discussed somewhat as in a proposed timber sale, except in a briefer manner, with considerably less detail. A description of the timber, including an estimate of the number of cups each section will cup, is given. An accurate description of the location o fthe permit and the situation, as to competitive bidders and other factors affecting the value of the timber, form an important part of the budget. The budget, with turpentine maps, is forwarded to the district forester for his consideration, and upon approval advertisement is immediately commenced. As a rule, the advertisements appear weekly in a city paper which has a circulation among local turpentine men. News items are prepared for local papers calling attention of the public to the fact that the timber is being advertised. In addition, placards are posted in all post-offices and clippings and letters sent to operators who might become interested; every attempt is made to sharpen the demand for the timber and to secure competitive bids. In some cases the rivalry thus stimulated has resulted in a 50 per cent increase over the minimum bid. As soon as the bids have been opened and the permits awarded, the preparation of the contract and bond is commenced, and within a week all papers have been executed and the first payment made.

This generally takes place in December or January, and the work of getting the area ready for cupping is started at once under the supervision of the district ranger. Plowed or hoed fire lines not less than 3 feet wide are made around each section, or if the tract happens to be in a contiguous tract, around the whole tract. These fire lines must be inspected by the district ranger before the tract is ready for burning. On a day mutually chosen by the operator and the ranger the tract is burned over under the supervision of the district ranger, the operator furnishing a foreman and a crew of from 5 to 10 men, who start at the outside boundaries of each section and burn toward the center, always following the fire and seeing to it that seedlings and saplings, unmarked trees, and raked trees are unharmed by the fire and at all times keeping the fire under perfect control. The fire consumes the ground cover and loose litter and destroys most of the blackjack oak, leaving the forest floor clear and the stand free of underbrush, so that it is easy to get around from tree to tree, as is necessary in working the crop for turpentine. The main feature, however, in the burning and the one that appeals most strongly, is the fact that absolute protection from fire results for at least a year after the burning. Protection at this time is highly essential, for if an uncontrolled fire were to run through the timber after the cups were hung and the faces exposed, not only would the cups and faces be ruined, but a great deal of damage would result to the timber.

Cup hanging is now in order. This stage of the process is a most critical one from the Forest Service standpoint, for if the cups are not placed properly much damage to the timber and waste of gum will result, and the administration of the permit will be marred by constant trouble with the operator, his foreman, and his laborers. It is nearly impossible to work a body of timber according to Government regulations unless the cups are placed correctly, to begin with, and unless the regulations are followed damage and waste are sure to result. The only serious trouble that has been met with in the enforcement of the regulations has been in a few of the early permits, where the Government supervision during the cup-hanging period was lax or inefficient. Rangers are instructed to be, and it is seen to that they are, absolutely unyielding in their enforcement of the regulations during this period.

A count of the cups is kept during the cup-hanging period. This count is checked by counting the crates of cups carried to the permit and stacked at the bunch grounds. An efficient cupping crew consists of 11 men, as follows: 1 woodsman or foreman, 1 teamster, 1 bark chopper, 3 broad-axe men, 3 mallet men, 1 cup hanger, 1 chipper.

The man with the bark axe precedes the crew, and under the cautioning eye of the ranger chips off the thick ridges of bark near the base of the tree at the place where the cup is to hang. This is the man who requires the most watching, to see that he does not put one cup on two-cup trees and two cups on one-cup trees; that he does not put a cup on a tree that should not be worked, and that he spaces the cups in such a manner that a bar of bark 4 inches wide is left at the narrowest place, and that the bar is not over 6 inches wide at the widest place. The gutter-axe men and the mallet men come next. The former are armed with heavy crescent-shaped broad-axes, which they hold against the tree at the point where the gutter is to be inserted, and an assistant drives it with a maul to a depth of about ¾ inch, leaving a gash in which is inserted the gutter tin horizontally and about 8 inches from the ground. Now comes the chipper, who chips a streak about 2 inches above the gutter; then the cup hanger, who drives a nail on which he sets the cup under the gutter. The teamster distributes cups and aprons from the wagon to the base of each tree. This description, of course, applies only when one of the modern horizontal gutter-cupping systems is followed, and does not apply to the older cup systems in which a deep cup and an inclined gutter are used. The crews start at daylight in the morning and quit at dark, and under an efficient foreman will put up from 400 to 600 cups to each gutter-axe man, or, in the case of the crew described above, from 1,500 to 1,800 per day.

From the time that cupping is completed until the last week of March nothing further is done to the timber. By April 1 regular chipping has commenced, and each week during the following months until the 1st of November a new streak is put on at the top of each face over the entire area, so that the face progresses up the trees at the rate of ½ inch per week. Rainy weather, labor troubles, etc., often cause the loss of several streaks during a season, and it is a fortunate operator who can get 30 or more streaks on his timber during a regular season.

The tin cups at the bottom of the face below the gutter generally hold about 3 pints, and are filled during an ordinary season once for every four streaks on the face, when the contents are dipped out with a paddle into a bucket, which, when full, is emptied into a dip barrel and hauled to the still.

The turpentine agreement, or, as it is commonly called by operators, "the permit," is modeled somewhat after a timber-sale contract, differing only as to the regulations. The following copy is self-explanatory:

UNITED STATES DEPARTMENT OF AGRICULTURE, FOREST SERVICE

TURPENTINE AGREEMENT

October 21, 1912, Florida National Forest

We, John Doe & Co., a corporation organized and existing under the laws of the State of Florida, having an office and principal place of business at Harper, State of Florida, hereby agree to work for turpentine certain timber in the Florida National Forest in accordance with our bid submitted in pursuance of a notice of sale duly given by publication. Said timber is all the longleaf pine timber not excepted under the terms of this agreement located on an area of about 2,280 acres, to be definitely designated by a forest officer before cupping begins in sections 4 and 10, T. 1 S., R. 26 W., T. M., and sections 28 and 32, T. 1 N., R. 26 W., T. M., within the Florida National Forest, upon which area it is estimated that 40,000 cups, more or less, may be placed. In consideration of the granting of this privilege to us, we do hereby promise to pay to the First National Bank of Albuquerque, N. M. (United States depository), or such other depository or officer as shall hereafter be designated, to be placed to the credit of the United States, the sum of sixty-one hundred and ten dollars ($6,110), more or less, as may be determined by actual count at the rate of one hundred fifty-two 75/100 dollars ($152.75) per thousand cups. The payments shall be made in four approximately equal installments, the first of which shall be in the sum of not less than $1,527.50, due January 25, 1913; the second on or before June 30, 1913; the third on or before January 1, 1914, and the fourth on or before June 30, 1914, credit being given for the sums, if any, hitherto deposited with the said United States depository or officer in connection with this privilege.

And we further promise and agree to work said timber in strict accordance with the following conditions and all regulations prescribed by the Secretary of Agriculture:

1. Timber on valid claims and all timber under other contract with the Forest Service is exempt from cupping under this agreement.
2. No tree will be cupped, chipped, raked, or worked in any manner until payment has been made in accordance with the terms of this agreement.
3. No gum or other product of the timber will be removed before the cups on the area have been counted by a forest officer. Title to the product of the timber included in this agreement will remain in the United States until it has been paid for as herein prescribed and removed from the tree.

4. No timber will be cupped except that on the area designated by a forest officer, and all timber on that area will be cupped except as herein specified.

5. No marked tree and no tree 9 inches or less in diameter at a point 4½ feet above the ground will be cupped; not more than one cup will be placed on trees from 10 inches to 14 inches, inclusive, in diameter; not more than two cups will be placed on trees from 15 inches to 24 inches, inclusive, in diameter, and not more than three cups will be placed on any tree.

6. So far as possible, the depth of all streaks will average one-half inch or less, not including bark. The width of the streaks will be so regulated that not more than one-half inch of new wood will be taken from the upper side with each streak. A No. 1 or smaller hack will be used for chipping. Bars or strips of bark not less than 4 inches wide in the narrowest place will be left between faces, and the edges of faces will be parallel with each other and be placed vertically up the tree. So far as possible, where more than one face is placed on a tree, one bar between them will not exceed 6 inches in width. Not more than one streak will be placed on any face during any one week, and not more than 33 streaks during any one season. The chipping will be uniform in depth from shoulder to peak. Faces not chipped in accordance with these specifications may be marked out and the cups removed by the forest officer.

7. One of the modern cupping systems with horizontal apron or gutter will be used, and the cups and aprons or gutters will be so placed that the shoulders of the first streak will be not more than 10 inches distant from the bottom of the cup, and the cups will be placed as near the ground as possible. No wood will be exposed on any tree by removing the bark below the gutter or aprons.

8. No unnecessary damage will be done to cupped trees, marked trees, or to trees below the diameter limit. Trees that are badly damaged during the life of this agreement, when such damage is due to carelessness or negligence, shall be paid for at the rate of $5.00 per thousand feet board measure, full scale. The forest supervisor shall decide as to the presence and extent of damage.

9. No cups will be placed later than March 15, 1913, without written permission from the forest supervisor, and all timber embraced in this agreement will be cupped before said date. The cupping will proceed with all reasonable speed.

10. Unless extension of time is granted, all timber will be chipped, dipped, scraped; the product and all cups, aprons, gutters, and nails removed, and each cupped tree thoroughly raked to the satisfaction of the forest officer not later than January 1, 1916.

11. No fires will be set to the timber, underbrush, or grass on the area covered by this agreement without the written permission of the forest supervisor, and during the time that this agreement remains in force we will, independently, do all in our power to prevent and suppress forest fires on the said area and in its vicinity, and will require our employees and contractors to do likewise. We hereby agree, unless prevented by circumstances over which we have no control, to place ourselves and our employees at the disposal of any authorized forest officer for the purpose of fighting forest fires, with the understanding that if the fire does not threaten our property or the area embraced in this agreement, we shall be paid for services so rendered

at the rate or rates to be determined by the forest officer in charge, which rate or rates shall correspond to the rate or rates of pay prevailing in the Florida National Forest for services of a similar character at the time the services are rendered; provided, however, that if we, our employees, contractors, or employees of contractors are directly or indirectly responsible for the origin of the fire, we shall not be paid for services so rendered.

12. All cupped trees will be raked in a workmanlike manner for the space of 2½ feet around each tree before January 1 of each year of the life of this agreement, and a fire line not less than 3 feet wide in the narrowest place shall be hoed or plowed around the area covered by this agreement in such a manner as to completely isolate it from adjoining lands. Natural firebreaks, such as creeks, swamps, roads, etc., may be utilized with the consent of the forest officer in charge. These fire lines must be made and receive the approval of the forest officer in charge before any cups are placed the first year or new streaks made at the beginning of each subsequent year.

13. Cabins, shelter camps, telephone lines, and other improvements necessary in working the timber covered by this agreement will be constructed on National Forest land only under special use permit.

14. The face chipped each season will not exceed 16 inches in height from the first streak of the season to the last streak of the season, inclusive of both streaks, and all chipping shall cease on such faces as have reached this limit and on the whole area when the average height of the season's chipping reaches this limit.

15. At the expiration of this agreement, unless the time is extended or a new turpentine agreement entered into, and at such times as the cups are moved or raised, the gutter tins or aprons will be pulled from the faces and no cutting or hacking of the faces will be practiced.

16. The decision of the Secretary of Agriculture will be final in the interpretation of the regulations and provisions governing the sale, cupping, and removal of the product covered by this agreement.

17. Work may be suspended by the forest officer in charge if the conditions and requirements contained in this agreement are disregarded, and failure to comply with any one of said conditions and requirements, if persisted in, will be sufficient cause for the termination of this agreement and the cancellation of all permits for other uses of the National Forest.

18. No Member of or Delegate to Congress, or Resident Commissioner, after his election or appointment, and either before or after he has qualified, and during his continuance in office, will be admitted to any share or part of this contract or agreement, or to any benefit to arise thereupon. Nothing, however, herein contained will be construed to extend to any incorporated company, where such contract or agreement is made for the general benefit of such incorporation or company. (Section 3741, Revised Statutes, and sections 114-116, act of March 4, 1909.)

19. This agreement will not be assigned in whole or in part.

20. The conditions of the sale are completely set forth in this agreement, and none of its terms can be varied or modified except in writing by the forest officer approving the agreement or his successor or superior officer, and in accordance with the regulations of the Secretary of Agriculture. No other forest officer has been or will be given authority for this purpose.

21. And as a further guarantee of a faithful performance of the conditions of this agreement, we deliver herewith a bond in the sum of $500, and we do further agree that all moneys paid under this agreement will, upon failure on our part to fulfill all and singular the conditions and requirements herein set forth, or made a part hereof, be retained by the United States to be applied as far as may be to the satisfaction of our obligations assumed hereunder.

Signed in duplicate this 14th day of January, 1913.

JOHN DOE & COMPANY,
By JOHN DOE, *President*.

Witnesses:
J. L. GRIFFEN.
J. E. BROXSON.

Approved at Pensacola, Fla., under the above conditions, February 8, 1913.

INMAN F. ELDREDGE,
Forest Supervisor.

A bond of from $300 to $500, to insure compliance with the terms of the contract, is required in all permits, although it is believed that a larger bond would have a better moral effect and would insure the Government more fully against unusual damage due to carelessness or recklessness on the part of the operator. Operators are generally allowed to make the payments in four installments, all payments to be made before the end of the second year of the three for which the permit is granted. The permission to burn over a tract is not made a part of a permit, but requires a separate written permission from the supervisor. This is done so that the practice may be stopped at any time that it may become desirable or necessary without altering the terms of the contract or rescinding any privileges which might be considered a part of the contract. All contracts are prepared with five copies; the original is retained in the safe of the supervisor and a copy is kept for his open files. The duplicate is sent to the permittee with a copy for his foreman, and a copy is sent to the district ranger.

The field administration of a turpentine permit consists largely of straightforward but critical inspections at frequent intervals. On new permits, especially where the operator has had no previous experience with Government regulations, the area is visited by the district ranger and thoroughly inspected each week. It requires very little time to inspect such work, since, as a rule, no more than two chippers are employed in a permit and a man's work is always uniformly the same over the area chipped by him each week. It is necessary to ride through only a part of each man's work and to measure a few typical trees in order to quickly find out whether or not the work is being done according to contract. If convenient, the ranger rides to the turpentine still, where he sees either the manager or the woodsman, whom he informs of the progress of the work and to whom he complains, if necessary.

Often he finds the negro chipper in the woods trotting from tree to tree, wielding his keen-edged, clumsy-looking hack with a free-handed swing and marvelous precision. With him the ranger frequently talks over such matters as he can without frightening the negro off of his job. This manner of attempting to get the work done according to contract is not encouraged, because it is very apt to end in the loss of the negro to the turpentine man. To the negro, rangers, marshals, and sheriffs are gentry to be avoided, if possible, and never under any circumstances to be cultivated.

Printed instructions for chipping Government timber are posted throughout each permit, so that both woodsmen and chippers may have the regulations constantly in mind. One of the instruction cards is here shown:

Instructions for Chipping Government Timber

1. Use number one or smaller hack and begin first streak as near the gutter as possible; in any case not more than 10 inches from the bottom of the cup.
2. Do not chip more than ½ inch deep.
3. Do not take more than ½ inch of new wood up the tree with each streak.
4. Leave bars at least 4 inches wide; draw in faces if necessary.
5. Do not spread the faces, but draw them in slightly as you go up the tree, in order to keep the bars the same width all the way up.
6. The Ranger may remove cups and tins from faces that are not worked according to these instructions.
7. When you find "U. S." stamped on a face, do no more chipping on that face.

All employees and subcontractors of the lessee are bound by the contract with the Government to respond to the call and be subject to the orders of forest officers in case of fires in this area and adjoining lands. They are also required to use every effort to protect National Forest areas from forest fires.

John Doe & Co.,
Lessee.

Inman F. Eldredge,
U. S. Forest Supervisor.

In the course of a day's riding a ranger can cover several permits, provided they are not too widely scattered, for most of the time in inspecting turpentine permits is taken up in riding from one permit to the next. If it is not convenient for the ranger to ride past the still on his inspection work, he interviews the operator over the telephone at night. He then prepares his weekly inspection report, which is a small form carried in the ranger's note book. It is prepared in duplicate, and one copy kept by the ranger and the other forwarded to the supervisor. The form is given below.

(FACE)

ST. DATE....................
FLORIDA TURPENTINE PERMITS.
....
STREAKS. (Number to date, average depth, and height.)
FACES. (Average width of bars, height of face, etc.)
TIMBER. (Number of dippings, per cent of death, dry face.)
AREA INSPECTED.
DETACH AND FORWARD TO SUPERVISOR.
INSPECTED BY....................
TITLE....................

ST. DATE....................
FLORIDA TURPENTINE PERMITS.
....
STREAKS. (Number to date, average depth, and height.)
FACES. (Average width of bars, height of face, etc.)
TIMBER. (Number of dippings, per cent of death, dry face.)
AREA INSPECTED.
(Ranger's Files.)
INSPECTED BY....................
TITLE....................

(BACK)

Answer these questions fully, using a separate sheet if necessary:

Did you call manager's attention to poor work?........................
....
....

Did you mark out any trees or faces; if so, why, and how many?.........
....
....

Has there been any improvement since last inspection?..............
....
....

Answer these questions fully, using a separate sheet if necessary:

Did you call manager's attention to poor work?........................
....
....

Did you mark out any trees or faces; if so, why, and how many?.........
....
....

Has there been any improvement since last inspection?..............
....
....

On the reverse of the form the ranger states whether or not there has been any improvement over last week, gives the number of faces that he has marked out, and states whether or not he has called the attention of the manager to the condition of the work. In case of permits being worked by operators whose men are familiar with Government regulations and who have experience of some years' standing, as a number of the operators in the Forest now have had, the permits are not inspected every week, but either semi-monthly or monthly. It has been found, however, that even under the best conditions frequent inspection is necessary in order to protect the timber from damage due to deep chipping, severing of bars, etc., and the only reason that a semi-monthly or monthly inspection is adopted, rather than inspections at weekly intervals, is because of the necessity of having the ranger cover more territory as the number of permits increases.

At intervals of a month or six weeks the supervisor or his forest assistant, in company with the district ranger, makes an inspection of each of the permits in the Forest. While the chief object of such inspections is to check the rangers' work and to keep the whole turpentine business well in hand, it is always made a part of the inspector's duty to visit the operator and discuss the permit fully with him in order to find out, if possible, the amount of production, the cost, the labor conditions, and anything else of value. The result of this inspection is reported in the following form:

OFFICER'S INSPECTION REPORT OF TURPENTINE PERMITS

FLORIDA NATIONAL FOREST

John Doe & Co.
10/21/12. Case Designation. *October 28, 1913.*

Date of inspection: *October 28, 1913.* Section: *10.* Township: *1 S.* Range: *26 W.* Ride: *Boiling Creek.* Name and title of officer making inspection, with assistant, if any: *I. F. Eldredge, Forest Supervisor, and J. C. Kircher, Forest Examiner.* Time consumed: *2 hours.* Condition of fire lines, raking, and fire precautions generally: *Needs raking badly; plowed fire line in need of replowing and straightening.* Detailed description of chipping, giving average depth of streak, width of bars, height of streak, height of face to date, number of streaks, appearance of work, etc.: *Chipping ½ inch or less deep; good and even; edge of faces fairly straight; bars good; streaks ½ inch high; faces average 15 inches outside; 26 streaks for season; work good; in need of dipping; cups 80 per cent full; not scraped.* General health of timber cupped and uncupped. Estimate of percentage of dry faces, lightning-struck trees, bug-infested trees, and other damage: *Good and thrifty; very little, if any, dry faces, bug infestation, or other damage; lightning damage.* Approximate production of gum or scrape for the whole permit, with reasons for any unusual production: *On account of the large number of weeks during which no chipping was done, the output of gum has been smaller than usual.* Action taken as regards removal of cups; instructions given ranger, woodsrider, or manager: *Copy of report sent Ranger Day.* Is the work being handled properly by the district ranger? Give full details, if necessary, on back of sheet: *Yes; but no instruction cards found or boundary notices on lines.* General remarks regarding labor conditions, result of conference with operator, prospects for the next year, unnecessary cost of production, etc.: *This has been a panic year with operators and the work shows it; instead of having 33 streaks, it has only 26; labor conditions have been excellent; prospects for next year very good.*

Signature: *Inman F. Eldredge,*
Title: *Forest Supervisor.*

One set of the forms is bound into a field book and is carried by the inspector and made out in the field while the details are fresh in his memory. Upon his return to the office the book is given to the clerk, who copies the reports on to loose forms of the same kind, which may be forwarded to the district office and the district ranger or filed in the supervisor's files. In all cases the original form remains in the field book for reference at the next inspection.

Owing to the constantly increasing number of permits, it will probably be impracticable to make a supervisor's inspection of the permits at such short intervals, and during the coming season it is proposed to inaugurate quarterly inspections instead. During the past year the card form of inspection record has been kept, but this is found to be cumbersome and entails unnecessary work on the clerk. It is believed that the presence in the files of the supervisor's report, together with the weekly reports from the rangers, will be sufficient record for the progress of a turpentine permit.

At the end of every season—that is, in November—chipping ceases and the scrape is removed from the faces. "Scrape" is the white gum which hardens on the face during the season. After this process, which takes some little time, the trees are hoed or weeded and left for the winter. Under Government regulations this raking consists in the removal of all grass, litter, and débris from around the base of each cupped tree for a space three feet wide. As soon as the timber has been hoed the area is ready to be burned over again (if it will do so). As stated before, each burning requires a separate written permit, and the tract is carefully inspected both by the ranger and supervisor before permission is given, and the date set for burning is carefully chosen in order to prevent burning on windy days or during a period of drouth, when it would be hard to control the fire. Before burning, however, the permit requires that the fire lines be replowed or rehoed in a manner satisfactory to the ranger.

It depends largely upon the district ranger as to whether or not a turpentine agreement is satisfactorily carried out by the operator. Without any exceptions, the operators are heartily in favor of the various regulations and requirements of the Forest Service. The difficulty arises in getting the negro turpentine hand to abandon the old system which has been beaten into him ever since the Revolutionary War. It requires a constant pressure, both from the operator and the ranger, to force the negro to follow the chipping requirements, and since the practice of peonage has become a dangerous performance, the negro can no longer be driven, but must be approached with great tact and diplomacy. The weakest point in the whole turpentine industry, and the one point which prevents its being as progressive as other industries have been, is the exclusive employment of negro labor.

Each permit or contract covers a period of three years, and at the end of that time the permittee is required to rake the timber thoroughly, to remove all cups and gutters, nails, and to replow and rehoe the fire line around the area. The tract is then inspected carefully and the percentage of dead and damaged trees ascertained. Unless the timber is in such condition that a rest is necessary, it is readvertised for the second period of working, which covers three years, and is put on the market at once. As a general rule, the company who held the permit for the first three years is the applicant and sole bidder for the second permit, and consequently leaves his cups and gutters stand in order to save the expense of their removal. At the end of the first six years of working the timber is rested for at least one year, and maybe for more, depending upon the condition of the timber. During this period of rest the areas must be given absolute protection from fire. The areas are then carefully inspected, and all trees upon which back cups may be placed are marked and counted, and the timber is put on the market for the third period of three years, after which it is again advertised for the fourth permit.

Unless the prices for naval stores increase considerably, it is not likely that it will pay to continue working the timber after the fourth permit, and it will then be ready for the saw. It is a well-known fact that the greatest waste in timber due to its operation for naval stores is due to the long interval that often elapses between its abandonment by the turpentine operator and the time it is felled by the logger. In the case of the Florida Forest it appears at present that there will be no danger of an unduly lengthened interval between the time it is ready for the saw and the time it is felled. This is apparent when it is remembered that over half of the gross area of the Forest is privately owned by large corporations, and has been or is being worked for turpentine at such a rate that it will be ready for the logger at least five years before the first Government timber comes on the market. In fact, a considerable portion of the privately owned timber in the Forest has already been abandoned by the turpentine operator and is now ready for the saw. The privately owned timber in the Forest lies in the form of alternate sections with Government timber. The timber-holding corporations must saw their timber within the next few years or lose enormously. To do this they must perfect means of transportation, and must organize, house, and equip logging crews and build sawmills. Just about the time that they are commencing to feel a shortage of their own timber the Government timber will commence to come on the market at the rate of approximately 14 sections per annum, in compact bodies conveniently located. It seems logical that not only will the interval of waiting between the hack and the saw be done away with, but that the best prevailing market prices will be obtained.

TURPENTINE POSSIBILITIES ON THE PACIFIC COAST

BY C. STOWELL SMITH

Delivered before the Society December 4, 1913

INTRODUCTION

In presenting this paper, the author feels that he is foreshadowing a bulletin on the same subject which is now in the hands of the printer and which should appear within the next few months. This bulletin will cover the results in considerable detail, a brief résumé of which it is the intention to give here.

HISTORY OF INDUSTRY

The turpentine industry in California is interesting from an historic standpoint. Its inception dates back to the period of the Civil War, when production of naval stores practically ceased in the Southeastern States and no supplies on hand were allowed to reach northern ports. Obviously it was essential for the success of the Federal naval forces to obtain a supply of naval stores for use in calking vessels.

In response to this demand California made every effort to stimulate the production of naval stores within the borders of the State. In 1862 the State legislature offered premiums of $500 for the first 1,000 gallons of turpentine produced and $300 for the first 100 barrels of pitch. These premiums brought a quick response, and were first awarded, in 1863, to J. W. Jacobsen, who owned an interest in a still in Marysville having a daily capacity of 100 gallons of turpentine. According to old records, the average season's yield of crude oleoresin was found to be 3 gallons per tree, or 25 barrels of turpentine to 1,000 trees.

In 1864 350,000 pounds of crude pitch were collected in Butte and Sierra counties, from which three distilleries made 7,250 gallons of turpentine and 1,150 barrels of resin, averaging 250 pounds. One company tapped over 20,000 trees. In Butte county, for the two years ending in 1866, 1,200 barrels of turpentine, 1,800 barrels of pitch, and 7,200 cases of resin were made. This activity continued until the conclusion of the Civil War, when production of naval stores was again resumed in the Southeastern States.

A desultory attempt was made to revive the industry in 1872, when a turpentine and resin plant was installed in San Diego, which supplied a local demand only, and soon disappeared.

As far as early records show, the only species tapped for naval stores was western yellow pine (*Pinus ponderosa* Laws). Evidently the products from this species were satisfactory and filled every requirement for naval stores, while conditions cut off production in the South. However, as soon as avenues of transportation were again opened and cheap negro labor was once more available, it was but natural that the production of naval stores on the Pacific coast should cease. Just before the shutting down of the last plant, however, an incident occurred which formed the beginning of a new industry. It was the usual custom for teamsters to haul supplies to the mines in the high mountains, and on the return trip bring down crude oleoresin to be distilled in the valley. It was the custom to "box" trees along the main wagon roads, beginning at a low elevation and gradually working up as the timber became exhausted. The kind of timber to be boxed—western yellow pine—had been carefully described to the teamsters, and they were in the habit of delivering to the stills oleoresin, which, upon distillation, produced turpentine. However, they soon exhausted the timber at low elevations, and were forced to box farther and farther up the mountains. Ultimately they reached an elevation of about 5,500 feet, and discovered no material difference in the timber, with the exception of the size of the cones, which they doubtless attributed to altitude. They gathered a load of this oleoresin and delivered it to the still below. Upon being subjected to the same degree of heat as was customary in the case of the oleoresin from western yellow pine, the still exploded, to the great astonishment of the owner. He was thus convinced that a new product had been discovered. Subsequent investigation showed that the volatile oil was heptane, ordinarily obtained from petroleum. The local name "abietene" was given to this new product, as it was believed that it was produced from one of the firs. Subsequently it was discovered in digger pine (*P. sabiniana* Dougl.), and later in Jeffrey pine (*P. jeffreyi* "Oreg. Com."). Undoubtedly the first oleoresin was obtained from Jeffrey pine, as it was found at an elevation far above the range of digger pine. A controversy has been going on for some time over the derivation of heptane from trees, entered into alike by chemists and botanists.[1] This newly-discovered product soon became extensively known throughout the mountains as a cure for many diseases. Whatever merit it may have had soon led to the formation of companies to exploit it. Several such companies were actively engaged in boxing Jeffrey pines and distilling the oleoresin from the time the turpentine industry declined up to the time that the National Forests were created, and thus shut off a supply of cheap timber. One company has persisted, largely on private land, but last year secured the tapping privilege on a small amount of Jeffrey pine on the Lassen National Forest, which should ultimately result in considerable business of this character.

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[1] See Pharmaceutical Review, Nov., 1904, article by W. T. Wenzell. Also Forest Service Bulletin 119, "An Examination of the Oleoresins of Some Western Pines," by A. W. Schorger.

In addition to the use of abietene as the basis of various remedies, which seem to be rapidly increasing, the oil may prove to have properties making it especially valuable for extraction purposes in place of the petroleum hydrocarbon fractions now used. An examination along this line is now being made, in co-operation with Prof. Edward Kremers, University of Wisconsin.

As a result of this early commercial work, the problems presented to us were to determine accurately the yields which might be secured from western species under different conditions—the composition of the oleoresins, the cost of production, and the effect of modern methods of tapping upon insect infestation and merchantability. The remainder of this paper will be devoted to a brief discussion of these subjects.

YIELD OF OLEORESIN

Western Yellow Pine (*California*)

The western yellow pine experiments were conducted during 1911-'12 on the Sierra National Forest, about 35 miles northeast of Fresno, at an elevation ranging from 3,500 to 4,500 feet. The stand was very open, and contained a sprinkling of young pines and scrub oak. Occasional patches of bear clover were found. Out of a total of 410 trees included 64 had been damaged by fire and 47 had been previously tapped in 1910. During the experiments careful meteorological data were kept, including the maximum, minimum, and mean temperature and precipitation. During 1911 the mean temperature from June 1 to November 30 was slightly lower than recorded for the Florida[2] experiments from March 17 to November 2. However, the diurnal range was much greater. Rainfall amounted to 2.16 inches. The maximum temperature, 108°, occurred in July and the minimum, 24°, in November. In 1912 the maximum, 98°, occurred in July and the minimum, 26°, in April.

McCoy cups and aprons were hung in accordance with the method used in the Arizona and Colorado experiments by Mr. H. S. Betts.[3]

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[2] Forest Service Bulletin 40, "A New Method of Turpentine Orcharding," by Chas. H. Herty.

[3] Forest Service Bulletin 116, "Possibilities of Western Pines as a Source of Naval Stores," by H. S. Betts.

Nine hundred and sixty-eight cups were hung from June 13 to 22, 1911, and part of the faces chipped. The first chipping was finished by July 7. Sixteen regular chippings and eight dippings were made. An average yield of .281 pound per cup per week was obtained. This is slightly greater than in the Florida experiments (.263 pound, chipped 31 times). As the experiments were not started until July in 1911, it was necessary to repeat the experiment during the first half of the summer of 1912 in order to approximate a full season. Accordingly 300 cups were hung and chippings made from April 19 to July 26, 1912, a total of 14 chippings.

During this period the trees yielded .299 pound per cup per week. Combining the early part of the 1912 season with the latter part of 1911, thus approximating a tapping season from April 19 to November 26, a yield of .299 pound per cup per week was obtained. It is thus apparent that under conditions similar to those found in these experiments a 28-chipping season in California will yield 12 per cent more oleoresin than a similar season in Florida. On a basis of a 31-chipping period[4] in Florida and a 28-chipping period in California, the latter still produces 2.6 per cent more oleoresin.

Further experiments are now being conducted with western yellow pine on the east slope of the Sierras, on the lava flow from Mt. Lassen, near Coppervale, Lassen county.

Western Yellow Pine (Oregon)

During 1912 similar experiments were conducted on the Whitman National Forest in northeast Oregon at elevations varying from 4,540 to 4,600 feet. The summer was unusually cold and detrimental to a successful yield. One hundred and ninety-nine cups were hung the latter part of May. During the succeeding 24-chipping season an average yield of .102 pound per cup per week was obtained. By reducing the season to 21 chippings, this was only increased to .111 pound per cup per week. Subsequent experiments under more favorable conditions have demonstrated the futility of further investigation in this region.

Jeffrey Pine (California)

The Jeffrey pine experiments were conducted in 1911 on the Lassen National Forest, about five miles north of Inskip, Butte county, at elevations ranging from 5,300 to 5,800 feet. The Forest is open and parklike, practically free from brush. A few western yellow pines were found. Consistently hot days and cold nights prevailed during July and August, an average range of 51° being registered during 24 hours in July. The maximum, 116°, occurred in July and the minimum, 20°, in November. Three hundred and sixty-two trees were tapped, of which 91 had fire scars, "cat-faces," or broken tops, and 76 had previously been "boxed" for abietene. Subsequently it was discovered that 20 of the trees included were western yellow pines.[5]

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[4] Standard.

Nine hundred and fifty cups were set and 17 chippings made beginning June 13-30—a yield of .173 pound per cup per week, or 61.5 per cent of the yield from western yellow pine on the Sierra National Forest during approximately the same period.

Further experiments are now being conducted with Jeffrey pine on the east slope of the Sierras near Bridgeport, Mono county.

Digger Pine (*California*)

The digger-pine experiments were conducted on the Sierra National Forest, near North Fork, Madera county, during 1911, at elevations ranging from 2,700 to 3,200 feet. The stand was very open, but brushy. Mature digger pines were associated with foothill oaks. A slight modification of chipping from standard practice was used. Owing to forest fires and damage from stock accurate yield data were impossible. It was estimated, however, that digger pine actually produced, under these adverse conditions, .062 pound per cup per week, or 22 per cent of the yield from western yellow pine over a similar period.

Single-leaf Piñon (*P. monophylla*) (*Nevada*)

The piñon pine experiments were conducted on the Mono National Forest, near the Sweetwater Ranger Station, in 1912, at an elevation of about 5,650 feet. The stand was pure, dense, and overmature. Undergrowth was generally lacking. Two hundred and twenty-six trees were originally selected, but subsequently 23 new ones were added to replace an equal number abandoned on account of insects. The highest temperature, 101°, occurred in May, and the minimum, 18°, in October. Eleven inches of snow fell during October. Three hundred cups were set, and the first chipping done May 10. Over a period of 21 chippings the flow averaged .0887 pound per cup per week, or not sufficient to warrant further consideration.

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[5] Owing to the similarity of extreme forms of Jeffrey and western yellow pine, it is practically impossible for a field man to differentiate them botanically. It is well known, that western yellow pine contains terpenes and no heptane and Jeffrey pine heptane and no terpenes. In order to settle the status of the so-called "cross-variety" pines that exhibited botanical characteristics common to both, 15 trees were selected as follows: Five typical western yellow pines, five typical Jeffrey pines, and five so-called "cross-variety" pines. These were tapped and the oleoresins kept separate. It was found that the oleoresin from the typical western yellow pines contained terpenes and no heptane; that from the typical Jeffrey pines, heptanes and no terpenes, and that from the "cross-variety" pines, terpenes and no heptane. In the opinion of the author, this establishes the fact that unless a pine is typically Jeffrey it must be considered western yellow.

A few cups were hung on lodgepole pine (*P. contorta* Loud) and sugar pine (*P. lambertiana* Dougl.), on the Sierra National Forest, in 1911, at altitudes of 6,000 and 5,800 feet, respectively. The yield, however, was so small as to be negligible.

COMPOSITION OF OLEORESINS

The following table presents briefly the results of determinations made at the Madison laboratory on oleoresins obtained from various species included in the experiments, with the exception of sugar and lodgepole pine, neither of which can be considered commercial possibilities at the present time:

Species.	Date of collection.	As taken.				Free from water and chips.	
		Water, per cent.	Chips, per cent.	Rosin, per cent.	Volatile oil, per cent.	Rosin, per cent.	Volatile oil, per cent.
Western yellow pine (Cal.)	Oct., 1910	1.2	0.8	79.5	18.5	81.1	18.8
Western yellow pine (Cal.)	Oct., 1911	1.0	1.6	81.1	16.3	83.2	16.7
Jeffrey pine (Cal.)[6].	Nov., 1911	5.4	0.3	82.2	12.2	87.1	12.9
Jeffrey pine (Cal.)..	July, 1913	1.69	0.47	87.88	9.96	89.78	10.17
Digger pine (Cal.)..	....	1.8	3.3	83.5	11.4	87.8	12.2
Single-leaf pinion (Nev.)...........	Dec., 1912	1.21	0.09	79.67	19.03	....	....
Single-leaf pinion (Nev.)...........	Dec., 1912	1.3	0.13	79.59	18.98	....	....

[6] Few western yellow pines included.

The volatile oil from western yellow pine oleoresin, which will undoubtedly enter the general market as turpentine, has a characteristic lemon odor, and its fractions possess a higher boiling point and index of refraction than the turpentines from the Southeastern States. The rosin appears to be identical with Southern rosins.[7]

Pure Jeffrey pine oleoresin produces nearly pure abietene (heptane) as its volatile oil and rosin of w. w. (water white) grade.

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[7] For a complete discussion of the volatile oils from Pacific Coast species see Forest Service Bulletin 119.

The oleoresin from digger pine produces a volatile oil consisting of nearly pure heptane, and in this respect resembles Jeffrey pine and differs from western yellow pine.

The volatile oil from single-leaf piñon has the same general properties as that obtained from *Pinus edulis* (see Bulletin 119).

COST OF PRODUCTION

The cost of production can only be estimated on the basis of reports compiled by forest officers in charge of the experiments on the Lassen and Sierra National Forests and a report submitted at the conclusion of a commercial tapping season on the Lassen. These reports have been condensed into the following table. It must be kept in mind that these estimates are based on results obtained by wholly inexperienced men. Actual costs can only be determined by actually conducting a large commercial operation over a considerable period:

Efficiency per man per day.	Lassen Forest—Jeffrey pine.		Sierra Forest—western yellow pine.
	Based on experiment.	Based on small commercial operations.	Based on experiment.
Number of cups and aprons distributed.	350–400	500	1,000–1,200 (with pack animal.)
Number of faces smoothed, ready for placing aprons	75–100	100[8]	200
Number of cups and aprons hung	50 (2 men 100–125)	100[9]	175–225 (2 men.)
Number of streaks placed	125–150	500	400–500
Number of cups dipped	200	750	300–400
Size of ideal crew for operation of 10,050 cups	10	4	8
Wages	$2.50–$3.00	$2.50	$2.00[10]

From these figures I have estimated the initial cost of placing 1,000 cups in flowing condition at $34.75. The operator will have to pay interest on this amount of say 20 cents during the life of the operation.

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[8] Time available for assisting in placing aprons.

[9] First streak also cut.

[10] Digger Indians; good workers and fairly intelligent.

The cost of operation per week will amount to about $8.45. During this period western yellow pine should average .299 pound per cup per week of oleoresin, or 299 pounds per 1,000 cups. This, upon distillation, should yield 53 pounds of turpentine and 245 pounds of rosin. Against this yield should be figured stumpage, cost of cups and aprons, cooperage, stilling costs, and selling costs. No attempt is here made to compute possible profits, since the price of naval stores is constantly fluctuating. Undoubtedly the costs given above can be materially reduced in a commercial operation.

Tentative prices for the turpentining privilege have been fixed in District 5 at $19.35 per thousand cups per year on western yellow pine and $45 per thousand cups per year on Jeffrey pine. These prices are subject to change as soon as more authentic data are secured.

EFFECT OF TAPPING UPON INSECT INFESTATION

On the western yellow pine experimental area on the Sierra considerable evidence of beetle work was found during the early part of the season. As chipping continued, however, infestation decreased, and, although beetle infestation had been general for three years before tapping, the experiment evidently did not increase it.

On the Jeffrey-pine area on the Lassen an effort was made to determine the ultimate effect of tapping upon insect attack. Two uniform areas were selected, each containing about 250 square feet. Area one contained both "boxed" and unboxed trees, the boxing having been done about 10 to 15 years before the investigation. Area two contained only unboxed trees. On the first area 36 boxed trees were alive and 4 boxed and 4 unboxed trees dead. On the second area 50 unboxed trees were alive and 4 dead. There were less deaths among the boxed trees than would be normally expected on an equal area covered with unboxed trees. All of the boxed trees are bearing cones and the foliage is a rich dark green. This gives a fairly reliable indication of the effect of modern methods of tapping.

A number of the single-leaf piñons on the Mono were badly attacked by the common bark beetle, *Ips confusus*. Out of the 226 trees selected for the experiment, 42 were attacked during the season, the principal attack taking place from June 2 to June 16, during which time 24 infected trees were noted. Of the trees attacked 18 were abandoned and 16 killed. These results preclude the tapping of single-leaf piñon in western Nevada, regardless of the question of yield.

EFFECT OF TAPPING UPON MERCHANTABILITY

In 1913 an investigation was undertaken to determine the effect of tapping upon merchantability. This resolved itself into two parts—first, a mill-scale study of butt logs from trees which were tapped 45 to 50 years ago by the "boxing" method, and, second, a mill-scale study of similar logs from trees tapped by the modern cup and apron system. As no trees of the latter class were available, it was necessary to start an experiment extending over a period of ten years. For the effect of the "boxing" method 97 butt logs were selected. Each log was scaled on the log deck, the average diameter inside bark, length, number of boxes, and amount of burn or decay being recorded. In scaling no allowance was made for cull. Tally of the lumber cut by grades was obtained at the grading table. Reductions in grade due to "pitch" and decay and all trimming due to these causes was recorded. In this way it was possible to secure not only the actual loss in board feet, but also the loss caused by reduction in grade. (Since fire damage to green western yellow pine timber is almost invariably followed by more or less infiltration of resin adjacent to the burn, burning greatly increased the damage due to boxing. It was impossible to determine the extent of this damage and to separate it from that which followed boxing only.) Many of the boxes had been burned out.

The total amount of lumber cut from the 97 butt logs was 62,405 feet board measure. Of this, 1,346 feet, or 2.15 per cent, was trimmed away due to boxing and resulting fire damage. On the basis of trees, instead of butt logs, this loss will amount to less than 1 per cent.

By reduction in grade the price of the lumber was reduced approximately $44.[11]

To determine the effect of modern methods of tapping, 200 trees were selected and tapped. Streaking will continue during the flowing season for five years. The trees will be cut and milled at the rate of 20 each year, in accordance with the following schedule:

200 tapped in 1913.
20 milled in 1914, after 1 year's tapping.
20 milled in 1915, after 2 years' tapping.
20 milled in 1916, after 3 years' tapping.
20 milled in 1917, after 4 years' tapping.
20 milled in 1918, after 5 years' tapping.

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[11] For a full discussion of these experiments see Forest Service Report entitled "Millscale Study of Boxed Western Yellow Pine," by C. A. Kupfer.

20 milled in 1919, after 5 years' tapping and 1 year's rest.
20 milled in 1920, after 5 years' tapping and 2 years' rest.
20 milled in 1921, after 5 years' tapping and 3 years' rest.
20 milled in 1922, after 5 years' tapping and 4 years' rest.
20 milled in 1923, after 5 years' tapping and 5 years' rest.

A careful mill-scale study will accompany each cutting.

SPECIAL INVESTIGATIONS

During the summer of 1912 experiments were made on western yellow pine on the Sierra National Forest to investigate several problems connected with turpentining, as follows:

(1) The effect of different heights of streaks upon yield.

One hundred and two cup trees were selected, one face on each tree being chipped with a streak ½ inch high and ½ inch deep. The opposite face was chipped with a streak ⅛ inch high and ½ inch deep. The faces streaked ½ inch high yielded 15 per cent more oleoresin than the others. This experiment is of value chiefly in determining the advisability of prolonging the life of an operation.

(2) The effect of chipping at short or long intervals upon yield.

Fifty trees carrying three cups were selected. The respective faces were chipped at 3, 5, and 7 day intervals. Calling the 7-day faces 100 per cent, the 5-day faces yielded 135 per cent of oleoresin and the 3-day faces 227 per cent in the same time. In addition to an increased yield of oleoresin, the faces chipped at the shorter periods yielded a higher per cent of volatile oil.

These results have an important bearing on the advisability of frequent chipping in the case of timber which is to be converted into lumber in a few years.

(3) Effect upon yield of shielding faces against sun and wind.

Twenty-five two-cup trees were selected, one face being protected by a canvas apron and the opposite one exposed to the elements. Contrary to expectations, the shielded faces showed a reduction in yield of 18.2 per cent.

(4) The rate of flow of oleoresin between chippings.

Ten two-cup trees were selected, and the faces chipped regularly at weekly intervals. Two periods of one week each in June and July were selected, during which periods the oleoresin was weighed as follows:

The faces were chipped early in the morning of the first day of each period and the oleoresin weighed at hourly intervals throughout the day. On the day following chipping, weighings were made at 3-hour intervals.

For the remaining days of the week three weighings were made each day, morning, noon, and night. During the first hour of the first day in June 12 per cent of the total flow for the day (24 hours) and 8 per cent of the total flow for the week took place. In July 8.4 per cent flowed during the first hour of the first day and 7.1 per cent of the total week's flow.

In June 92.2 per cent of the total week's flow occurred during the first two days, and in the July experiment 95.6 per cent during the same period.

These experiments further emphasize the fact that after the first two or three days following chipping flow practically ceases.

(5) Flow from north and south faces.

Twenty (20) cups were selected on the north side of various trees and a like number on the south side. One, two, and three cup trees were represented in each set selected. North faces yielded 95 per cent as much oleoresin as those on the south side.

(6) Effect of solvents and brushing upon flow of oleoresin.

Five solvents were selected as follows: Gasoline, kerosene, 32-gravity gas oil, California pale oil, and signal oil. An excess amount of these solvents was painted on faces alone, and in combination at intervals of 24 hours, and 3 days after chipping. Several faces were left untreated for comparative purposes.

None of the solvents produced enough additional flow to justify the expense of using them.

Treatment with a very stiff brush produced a flow about equal to a very light chipping, and this method warrants further investigation commercially.

SUMMARY

The California experiments show a yield of oleoresin from western yellow pine about 12 per cent greater than that obtained from southern yellow pine in average operations in Florida, if the comparison is made on the same period of time for both. On the basis of the total season of flow in Florida and the season actually covered by the experiments in California, the latter produced 2.6 per cent more oleoresin than the former. This may be increased by beginning operations earlier in the spring in California than was done in the experiments (April 19). The turpentine produced in California probably will be satisfactory for industrial purposes. The low yield from western yellow pine in Oregon precludes its use for turpentine at the present time.

Jeffrey pine in California yields somewhat less oleoresin than western yellow pine. The principal constituent, heptane (abietene), cannot be used as turpentine, but has already found a considerable market in the manufacture of various medicinal products, and a further market may be developed as an extractive, in place of petroleum hydrocarbon fractions now used.

The rosin from both of these pines is high grade.

Digger pine cannot compete with Jeffrey pine in the production of heptane until the supply of the latter is exhausted, due largely to the low yield of oleoresin, but partly also to the difficulty of chipping.

Single-leaf piñon, lodgepole, and sugar pine yield such a small amount of oleoresin that their commercial exploitation is impossible, unless some special use is found for the particular oil produced that would justify a high price.

DISCUSSION

BY W. H. LAMB

The suggestion contained in Mr. Smith's paper on "Turpentine Possibilities on the Pacific Coast," that chemical analysis may solve the difficulties involved in distinguishing Jeffrey pine from western yellow pine, is very attractive to the systematic botanist. Much doubt exists as to the status of these closely related forms. There are a number of differences which are very useful as distinguishing features, but which cannot be regarded as absolutely dependable. Young trees of yellow pine have light bark, as distinguished from the gray, nearly smooth bark of Jeffrey pine. The bark of the older trees is also distinct. That of yellow pine is russet red and divided into broad, regular plates, while that of Jeffrey pine is dark red-brown, deeply furrowed and divided into narrow ridges. The leaves of yellow pine are bright yellow-green, while those of Jeffrey pine are blue-green. The cones of yellow pine are from 3 inches to 6 inches long, and cones of Jeffrey pine 6 inches to 11 inches. All of these differences are relative, and generally require the presence of both forms for comparison.

The occurrence of heptane, or abietene, in Jeffrey pine and the occurrence of turpene in yellow pine, as pointed out by Mr. Smith, would suggest the possibility of distinguishing these two forms by chemical analysis, as heptane differs materially in its properties from turpene. the principal constituent of the more commonly known turpentine oils.

The systematic botanist feels that such methods of diagnosis can be made very useful in distinguishing closely related forms, but that such methods cannot contribute greatly to the distinction of species until science has established a closer relationship between morphology and physiology than now exists. The difficulty of arriving at definite chemical standards for comparison, and of determining just how much variation in plant constituents should be taken as evidence of a botanical species, will render such methods of diagnosis extremely difficult. The chemical constituents of plants are often known to vary where there are no evident morphological differences, and again, among plants differing widely in morphology, the chemical constituents have been found to exhibit little or no variation.

Of particular interest is the observation that digger pine and the firs also produce heptane. Personal observations of the internal leaf structure of western conifers has disclosed the fact that certain trees which produce heptane have leaves whose internal structure is slightly different from the leaves of trees producing turpene. The leaves of *Pinus ponderosa* have a thin-walled layer of cells next to the epidermis. The leaves of *Pinus jeffrey* have no thin-walled layer of cells between the epidermis and the strengthening cells beneath. This structure is also characteristic of *Pinus sabiniana*. Corelation of these facts would indicate that in some way the absence of this thin-walled layer of cells may affect the photosynphetic processes in the leaf.

Recently a collection of pine cones, accompanied by foliage, were sent in for determination. One-third of these were marked "Yellow pine," one-third as "Jeffrey pine," and those remaining as "Cross varieties." In determining these specimens, two factors were considered: one furnished by the internal structure of the leaf and the other by the shape of the cone scale. The first was selected on the authority of Coulter and Rose,[1] who demonstrated that the leaves of western yellow pine have a thin-walled layer of cells next to the epidermis, and that the leaves of Jeffrey pine have no thin-walled layer of cells between the epidermis and the strengthening cells beneath. The second factor is based on the shape of the cone scale. Personal observations in the field and in the large herbaria of the United States have uniformly sustained this cone scale distinction between yellow and Jeffrey pine. The cones of yellow pine have scales with a short, broad prickle on the thickened apex (Fig. 1). The cones of Jeffrey pine have slender, down-curved prickles on the somewhat thickened apex of the scales (Fig. 2). All of the yellow-pine cones were found to have a typical *ponderosa* cone scale.

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[1] Botanical Gazette, XI, ii, p. 302. 1886.

All of the "cross variety" cones were also found to have a typical *ponderosa* scale. All but one of the Jeffrey-pine cones were found to have a typical *jeffreyi* cone scale, the exception proving to have a typical *ponderosa* scale.

Examination of the internal structure of the leaves was made with cross-sections cut between pith with a hand razor, mounted in glycerine, and examined under high magnification. All of the yellow-pine leaves were found to have a thin-walled layer of cells next to the epidermis (Fig. 3). All of the "cross variety" of leaves were found to have the same structure. All but one of the Jeffrey-pine leaves were found to have no thin-walled layer between the epidermis and the strengthening cells beneath (Fig. 4). The exceptional "Jeffrey"-pine leaves were found to belong to the "Jeffrey"-pine cones, which had been referred to *Pinus ponderosa*.

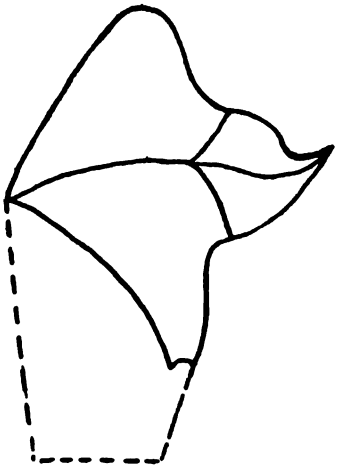

FIG. 1

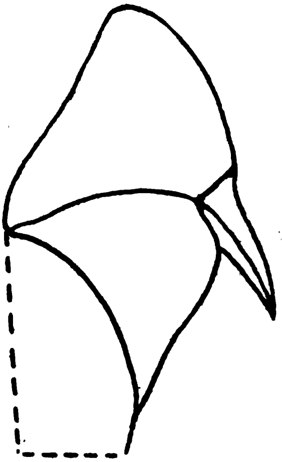

FIG. 2

It is apparent, both from this examination of the cones and of the leaves, that there were no intermediate forms at all. In every case the cone and foliage determinations were identical. All of the specimens with the short, broad prickle on the thickened apex of the cone scale (Fig. 1) had leaves in which there was a thin-walled layer next to the epidermis (Fig. 3). All of these specimens with slender, down-curved prickles on the moderately thickened apex of the cone scale (Fig. 2) had leaves in which there was no thin-walled layer of cells between the epidermis and the strengthening cells (Fig. 4).

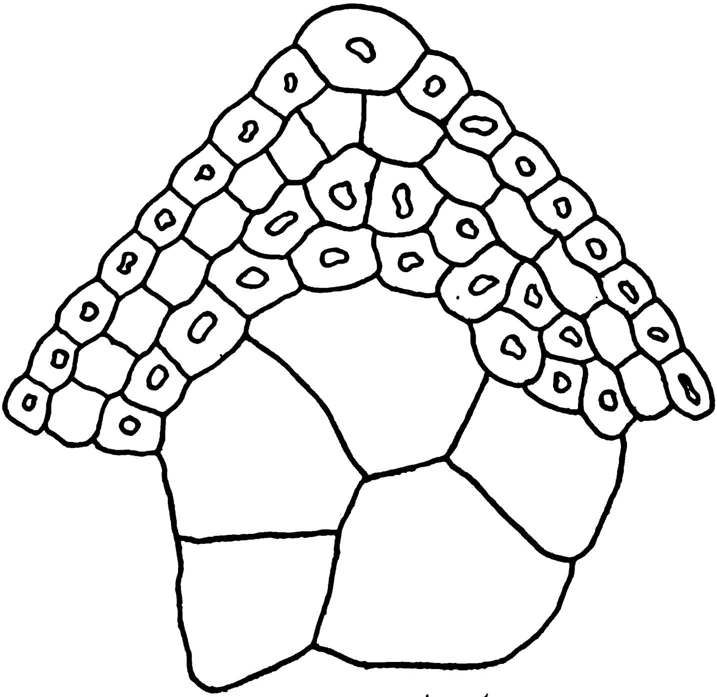

FIG. 3

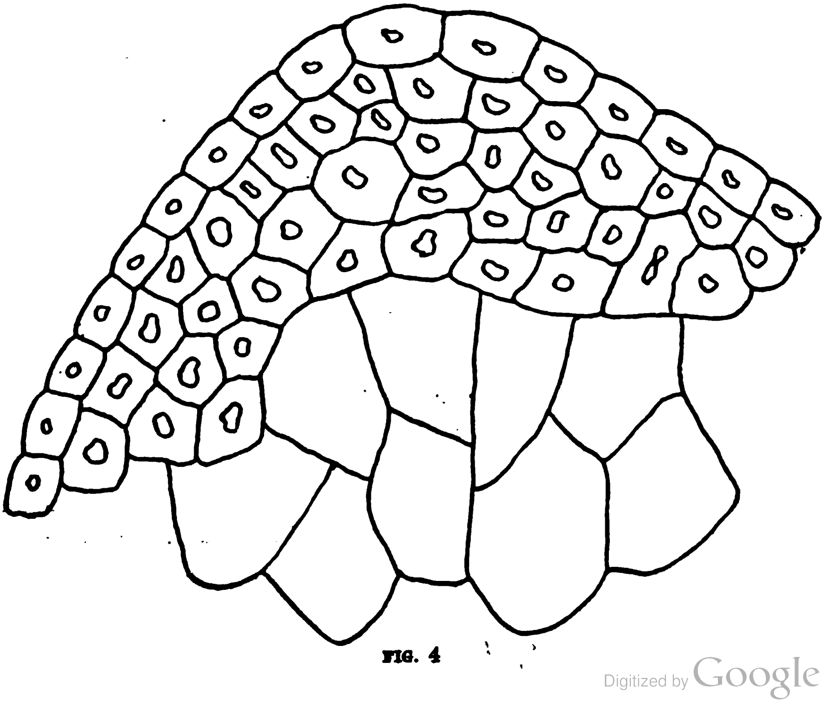

FIG. 4

STUDY OF PROTECTION FINANCES AND FIRE PLANS

BY J. F. PRESTON

Contributed

DISTRIBUTION OF PROTECTION MONEY

The first problem to be solved in the protection of a large area, such as is included in the Forests of District 1, is the correct distribution of the available funds on the different Forests in order to secure the maximum protection for the money expended. To do this it is necessary to know the relative protection value of each Forest and the factors which together make up this protection value. The simplest method of distribution of funds would be by area, allotting to each Forest the money available in accordance with its size. But this method would be grossly inaccurate and would be totally disregarding the very evident factors which make up the risk. The first attempt at getting a real basis for the distribution of money between Forests was the preparation by each of a fire plan showing the number of patrolmen needed for proper protection from the standpoint of each Forest. These fire plans were based almost altogether on experience and judgment of the men in charge. There was a wide variation in the intensiveness of the patrol considered necessary and an equally wide variation in the methods of using the money which might be allotted. A tabulation of the number of men needed for each Forest showed a good many inconsistencies, which were in part eliminated simply through the judgment of the district officers and the knowledge of the different Forests which they had acquired. It was perfectly apparent that this method of distribution of money was very likely to be unfair because of the fact that the men in the district office might happen to know a little more about one Forest than another, and this personal knowledge was too likely to influence them in allotting a larger proportion of the money than the Forests were really entitled to in comparison with others. One of the difficulties experienced was the inflexibility of the system. If the total amount of money which the different fire plans called for was available, this plan would undoubtedly result in very good protection. There has never, however, been a sufficient amount of money available to provide the number of patrolmen which the fire plans called for, and it was difficult to use these figures in making adjustments to fit the amount of money in sight. In departing from the fire plans it was always a pretty serious question in the mind of the man who was responsible as to whether or not the adjustments which he made were really the right ones.

This need for a better basis for the distribution of money resulted in an attempt to draw up fire plans based on the liability or the value of destructible resources and the risk. Every one admitted that these two factors were the fundamental ones to consider in arriving at a protection value for each Forest. Most of the Forests in District 1 prepared tabulations in considerable detail showing the liability and the risk and the control planned. Practically none of them, however, made any consistent attempt to use the figures for liability and risk in the distribution of money. The old fire plan based on judgment was still the one which was really in effect. In fact, no one really knew how to use the liability and risk factors, although all felt that they were fundamental. After studying the use to which these factors could be put, there was some question in my mind as to whether or not these were the only factors to be considered. In order to eliminate the errors and variables due to judgment, it was quite essential to base the distribution of money to the different Forests on a scientific study of the fire-protection factors, and the following methods have been devised in an attempt to do this:

Railroads

Railroad fires stand out by themselves throughout the district as a very great and at the same time very specialized source of danger. The records show that since 1908 50 per cent of all the forest fires which have occurred in this district are due to railroads. The danger to any Forest from this source is in direct relation to the mileage of the railroads through the Forests and the kind of fuel which they burn. It is perfectly evident also that this source of danger can be controlled, and that it must be controlled if we are to have any protection at all, without considering the risk from other sources or the value of the resources at stake. In other words, this is a protection factor which must be considered alone. Therefore the first step is to decide upon the number of men on the different Forests needed for railroad patrol and set aside sufficient money to provide for these.

Division into Groups

All other sources of danger are affected by the conditions existing on the different Forests—primarily the climatic conditions and inflammability. The next step which naturally suggests itself is a division of the Forests into groups where the climatic conditions are similar. This division has been made into the following groups: Eastern Montana, including the Dakota Forests; western Montana, and Idaho. This division is based again largely on judgment and experience, but it is perfectly evident that the fire risk in the three groups is very essentially different. The problem is to devise some method of actually measuring the risk and getting a correct distribution of the funds between these three groups.

Factors of Protection Value

The distribution of protection money to the three groups is determined by a consideration of the following factors: (1) gross area; (2) accessibility; (3) liability or the value of destructible resources; (4) the risk.

The gross area has been considered merely the proper check on the other factors. Other things being equal, certainly the distribution should be based on area, and area should therefore receive some consideration.

Accessibility has a direct bearing on the control, since the less accessible a Forest or a group of Forests is the more intensive should be the control. The accessibility is stated in miles per township to the nearest wagon road. The exact method of arriving at these figures will be taken up later.

Liability is figured in dollars based on present values.

The risk is divided into two parts, the first being the total number of fires, except railroads, which have occurred in each group of Forests since 1908; and the second is the damage which these fires have caused, figured in dollars. The first of the risk factors shows the possibilities, or rather the probabilities, of the sources of danger, and the second measures pretty well inflammability of the cover and the relative climatic conditions.

All of these factors are stated, first, as absolute figures and, second, as relative figures given in per cents of the total. It should be observed that the absolute figures are of no significance at all so long as the relative figures are all right. We know certainly that we have no accurate absolute figures, so that this fact is quite important. It is much easier to secure figures showing the relative value than it is showing the exact value. This makes five factors to be considered—one of area, one of accessibility, one of liability, and two of risk. The per cents in each group of the five factors are averaged by adding and dividing by five, giving equal weight to each factor.

General Average

The final figure is the per cent of protection money which should be given to each group of Forests or the relative protection values plus the number of men needed for railroad patrol. With the data available these general average per cents work out as follows:

	Per cent.
Eastern Montana	17
Western Montana	36
Idaho	47

and for railroad patrol:

	Men.
Eastern Montana	5
Western Montana	26
Idaho	7

Comparison with Fire Plans Based Purely on Judgment

If these factors and the manner of using them are correct, the study shows that both eastern Montana and Idaho should be given slightly more patrolmen, and that western Montana should be slightly decreased. Following is a comparison of the figures:

	Judgment basis (patrolmen).	Scientific basis (patrolmen).
Eastern Montana	82	89
Western Montana	220	203
Idaho	229	239

These figures include the men needed for railroad patrol.

Consideration of the Groups

The distribution of the money to the Forests in each group is based on two general principles: The first is that wherever fires occur with sufficient frequency year after year sufficient patrolmen should be placed in these localities to discover and extinguish these fires. This is regardless of the value of resources at stake or any other factors. If we know where to expect the fires, it is surely good business to assign the patrolmen so that these fires will be stopped. This force is known as the *fixed patrol.*

The second general principle is that a certain force is needed on each Forest for a more or less blanket control. In other words, there are a number of fires constantly recurring whose even approximate location cannot be foretold, and in order to control these fires it is necessary to scatter the patrolmen after a more or less blanket system, attempting as nearly as possible to watch all parts of the Forest in order to detect possible fires. The chief source of danger is, of course, lightning. The distribution of men for the blanket control is or should be in direct relation to the value of the resources at stake, the accessibility of the Forests, and the possibility or probability of fires starting. This force is known as the *blanket control force.*

Methods of Distributing Funds Between Forests

Making use of these two principles, it is possible to fix a minimum absolute number of patrolmen for each Forest, and an additional indefinite number to be allowed in proportion as that Forest stands in the relative rating on the factors, liability, accessibility, and risk.

In the actual method of distributing this money a tabulation is prepared showing in the first column the number of patrolmen needed on each Forest for railroad patrol, and in the second the number of patrolmen needed to watch for fires in special localities where the history of the Forest shows that fires occur year after year. This would include fires caused by campers, settlers burning brush, sawmills, incendiary, and lightning fires where they occur in distinct zone; the third column showing the liability, accessibility, and risk, figured in per cents, and a final column giving the general average for each Forest in the group. Area has not been considered in distribution of money between the Forests in the same group, because this factor has already been considered in the general group study and is considered indirectly under accessibility. The areas of the different Forests in the same group really do not mean a great deal. Mere bulk of territory means nothing, while liability, accessibility, and risk are all-important. The accessibility is figured in miles per township to the nearest wagon road; the liability is figured in dollars for each Forest, the figures given by the different supervisors being correlated with the figures for the district and for each of the Forests in order to secure at least fairly good relative figures. For the factor of risk there has been used simply the number of fires caused by lightning on the different Forests since 1908. This is the only risk factor which seemed to be at all comparable. The general average for each Forest in the group is thus obtained in per cent, which represents the per cent of protection money or the per cent of available patrolmen to which each is entitled for blanket control.

Use of Results by Groups

This gives a fixed number of patrolmen to be allotted each Forest year after year, or the *fixed patrol,* and a flexible and sure way of making adjustment of the additional number available, or the number of men making up the *blanket control force.* The fluctuations from season to season are easily taken care of. This method is based on sound basic factors, and to a very large extent eliminates individual judgment and bias due to particular knowledge of certain portions of the district. In fact, an intimate knowledge of the district is really not essential.

One other factor might be taken into consideration, and that is the number of patrolmen available paid by the timber protective associations or other co-operators. This has not been considered (1) because the amount of money so far available has provided only about 80 per cent of the patrol which is considered necessary, and (2) because it is felt that we should give the areas where co-operators spend their money a little better protection, if anything, than other areas. The number of co-operative patrolmen could, however, be very easily figured under this method of distribution, if it was considered advisable.

FIRE PLANS ON INDIVIDUAL FORESTS

Methods which might apply to the distribution of money by regions and by Forests might not apply to individual Forests. Certainly the general principles should control in the distribution of money on particular Forests as in distribution between Forests and between groups. It seems, however, from the extent to which the method has been tested, that it is possible to use the same methods, with very slight modifications, in applying the principles to the distribution of patrolmen for control and fire-fighting on individual Forests. Since this distribution is the chief, and perhaps the most essential, part of a Forest-fire plan, its correct use will assist greatly in the formulation of a complete fire plan. The application of these principles to individual Forest-fire plans furnishes a standard by which to measure them and a means to detect and demonstrate their weakness or strength. It also tends to eliminate and smooth out variations due to the judgment of the different supervisors, and approves or disapproves the advisability of any plan of distribution now in effect.

Steps in Theoretical Forest-fire Plan

The first essential is a map of the Forest on which is plotted all fires which have occurred as far back as the records extend, showing the location. It shows where the fires are more or less bunched year after year furnishes the data for the fixed patrol mentioned under group distribution. It shows where the fires are more or less bunched year after year, and where the risk is sufficiently concentrated to justify assigning a patrolman to a definite point or patrol area. In addition to the record of fires, it is also essential to know the areas frequented by campers, and any changes which might cause fires in particular areas where the records show no fires, or very few fires, have occurred in the past. These places can, however, be easily spotted. While there is ample room for the exercise of judgment in fixing the number of patrolmen and the patrol routes to take care of fires in this class, there cannot be a very wide variable. These patrolmen will be expected to locate the fires, and, ordinarily, extinguish them also.

The second step is the tabulation showing the value of destructible resources, risk, and accessibility by districts, and, of course, the same data shown on a map of the Forest is of additional assistance. In these figures the relative ratings in per cent are figured out for the different districts of the Forests in nearly the same way as was done for the Forests in each group. The accessibility is arrived at by figuring the distance from the nearest wagon road or railroad to a possible fire in the center of each township, 90 per cent of which lies in the district, measuring the distance along a trail or down the drainage. The exact mileage is not essential so long as the figures for each district are arrived at in the same way. The presence of railroads and automobile roads, and the time required to get men to the scene of the fire, can easily be taken into consideration for individual Forests. The risk is probably the most difficult factor to determine. About the only figure which it is possible to use seems to be the number of scattered fires which have occurred in the different districts of the Forest which are not covered by the fixed patrol mentioned previously. In other words, these are the numbers of fires which the records show have occurred and whose location cannot be foretold. It is believed that these figures of scattered fires are a safer guide than simply the record of lightning fires. The final figures in per cents applying to the total number of patrolmen available for the Forests, minus the number already provided for under fixed patrol, show the distribution of the blanket control force among the different districts. It will be noted that only those factors have been considered which can be expressed by figures and the values measured. There are other rather intangible factors, but they are of little value for practical use.

The distribution of these blanket patrolmen is based on the principle that only a general control can be maintained or is justified by the risk. The reporting and the fighting of fires must as a general proposition be figured separately. We cannot expect to be able to stop all fires of this class when they are small. The only question is, how quick the action can be, and it means the development of fire-fighting machinery separate from fire patrol. I do not believe that any system of control which does not take into consideration the fact that some of the men should be fire-fighters and some merely reporters of fires will be successful. It is difficult to see how a system of control can be made successful which depends on the patrolmen both discovering and extinguishing all the fires.

Results

Out of this blanket control force must come packers, teamsters, lookouts, and reserve fire-fighters, and men at central points to answer the telephone and start the fire-fighting machinery. A fire-plan study along this line gives a scientific basis for checking the distribution of men, and makes possible the preparation of a pretty safe fire plan without a detailed personal knowledge of the Forests. The exact distribution of the men can, of course, be made only after a careful study of each district, and must be modified by the status of improvement, development, the presence of camping sites, horse feed, etc. The other details in the preparation of a fire plan cannot be discussed here, since the only object of this discussion is to show a method of using the basic factors in determining fire-protection value from the standpoint both of the district office, the supervisor, and the ranger.

An Adequate Patrol

The final determination of the maximum number of patrolmen which should be allotted each Forest when funds become available cannot be decided until more accurate data is available showing the value of the resources and the risk and a more complete study of the fire-protection problem has been completed. The number of men for fixed patrol and the increased number needed for bad seasons can be very accurately determined now. The number of men needed for blanket control can be fixed only after the lookouts have been carefully chosen and equipped and experience and experimental study show their efficiency. The studies so far completed indicate clearly that we are justified in putting on the number of patrolmen essential, with a good, effective organization, to the control of all fires—which means limiting every fire discovered by the blanket control force to an area not exceeding 40 acres and every fire discovered by the fixed patrol to an area not exceeding five acres. Data so far available indicate that expenses for protection, including fire-fighting, can be held to a figure representing an insurance rate of about one-tenth of one per cent on the present value of destructible resources.

The tabulations referred to are attached:

Division between groups of forests representing similar climatic conditions

Protection factors

Name of group.	Area.		Accessibility.		Liability.		Risk.		Total damage since 1908, all fires.		R. R.	Average all factors except R. R.
			Average distance of possible fire from nearest wagon road or railroad.		Value of destructible resources.		Total number fires since 1908, except railroads.				Men needed, R. R. patrol.	Per cent of protection money available.
	Million acres.	Per cent of total.	Miles per T.	Relative ratings, per cent.	Million dollars.	Per cent of total.	No.	Per cent of total.	Thousand dollars.	Per cent of total.		
E. Montana												
W. Montana												
Idaho												
Totals												

Division between forests, same group

Blanket control force

Name of Forests.	Fixed patrol.			Risk.		Accessibility.		Liability.		General average.
	Sources of danger.					Average distance of possible fire from nearest wagon road or railroad.		Value of destructible resources.		Figures of relative protection.
	R. R. men.	All other men.	Total men.	No. of lightning fires since 1903.	Per cent of total for group.	Miles per township.	Relative ratings, per cent.	Million dollars.	Per cent of total.	Value, per cent.
Absaroka										
Beartooth										
Beaverhead										
Total										

Sample tabulations, forest-fire plan—Missoula Forest

Distribution of *fixed patrol* (fire caused by campers, burning brush, railroads, and lightning in special zones).

District.	Speeders.	Lowland patrol.	Highland patrol.	Total.	Increase, bad season.	Locations.
1	0	0	0	0	1 lowland	Middle Fork, Rock Creek
2	0	0	0	0	1 lowland	Main Rock Creek Road
3	1 (?) Clinton to Beartooth	1	1	3	0	Lower Rock Creek, N.E. Corner District
4	1 Blackfoot River	1	0	2	1 lowland Blackfoot and Gold Creek	Seely Lake to Salmon Lake, Blackfoot, and Gold Creek
5	0	2	0	2	1 lowland Alice Creek	Woodworth, Cooper Lake, Alice Creek
Forest	2	4	1	7	4	

For all fires except general primary control.

Average season, 7; bad season, 11,

	Speeders.	Lowland patrol.	Highland patrol.	Total.
Average season	2	4	1	7
Bad season	2	8	1	11

Sample tabulations, forest-fire plan—Missoula Forest

Distribution blanket control force

Factors

District.	Value of resources.		Accessibility.		Risk.		General average, per cent.	Number of patrolmen on basis of total of 18.
	Thousand dollars.	Per cent of total.	Average distance to wagon road per township miles.	Relative ratings, per cent.	Scattered fires since 1908 not covered by fixed patrol, bad season.	Per cent, total.		
1	550	11	5.2	20	0	0	10	1
2	600	12	4.0	15	7	44	24	2
3	1,200	24	3.8	14	2	12	17	2
4	1,850	37	5.0	19	7	44	33	4
5	800	16	8.7	32	0	0	16	2
Totals.	5,000	100	26.7	100	16	100	100	11

Total each district, average season.

District.	Patrolmen.
1	1
2	2
3	5
4	6
5	4
Forest................	18

Sample tabulations, forest-fire plan—Lolo Forest

Distribution of fixed patrol

Districts.	Average season,			Increase, bad season.	Location of patrolman.
	Railroads.	Campers, brush burning, etc.	Lightning zones.		
1	....	1		1	Lolo Creek; lowland patrol
2	....	2	1	0	Nine Mi. Creek (lowland) Mill Creek (highland) Gilman's (highland)
3	1 Fish Cr. to Huson	0	0	0	
4	1 Cedar Creek to Fish Creek.	0	1	0	St. Patrick's Peak Lookout
5 6 }	1 St. Regis to Cedar Creek	0	1	0	Lookout, head of Spring Gulch.
7	1 St. Regis to Paradise	1	0	0	Mullan Gulch (lowland)
8	1 Haugan to St. Regis	1	0	1	Big Creek, Deep Creek, and wagon road (lowland)
9	1 Summit to Haugan	1	0	0	Parker and Silver Creek (lowland)
Forest	6	6	3	2 4	 R. R. patrolmen.
				6	

	Speeders.	Highland.	Lowland.	Lookouts.
Fixed patrol, average season, 15	6	2	5	2
Fixed patrol, bad season 21	10	2	7	2

Balance of available patrolmen to be distributed for primary control either as lookouts or highland patrolmen and always kept in touch with telephone.

Distribution in accordance with value of resources, accessibility, and risk.

Sample tabulations, forest-fire plan—Lolo Forest

Distribution blanket control force

Factors

District.	Value of resources.		Accessibility.		Risk.		General average, per cent.	Number of patrolmen on basis of total of 25.
	Thousand dollars.	Per cent of total.	Average distance to wagon road or railroad miles per township.	Relative ratings, per cent.	Scattered fires since 1908 not covered by fixed patrol, bad season.	Per cent total.		
1	570	13	4.5	13	6	23	16	2
2	532	11	2.0	5	4	15	10	1
3	190	5	2.5	7	0	0	5	0
4	711	16	10.1	30	4	15	20	2
5	466	10	5.3	16	3	12	13	1
6	284	6	2.0	6	3	12	8	1
7	530	11	4.0	11	3	12	11	1
8	1,025	23	2.3	7	2	7	12	2
9	192	5	2.0	5	1	4	5	0
Forest.	4,500	100	34.7	100	26	100	100	10

Totals by districts average season, fixed patrols, and blanket control force:

District.	Patrolmen.
1	3
2	4
3	1
4	4
5	2
6	2
7	3
8	4
9	2
Total	25

Speeders	6
Other fixed patrols	9
Blanket control	10
Total	25

THE ECONOMIC ASPECT OF SLASH DISPOSAL

BY ELERS KOCH

Contributed

I recently had a conversation with a man who is conducting a tie and logging job in Government timber on the Lolo Forest. His contract requires him to pile all of the brush from his logging operations, and, as usual, it has been the most difficult phase of the contract to enforce. He has been doing a good deal of figuring on the brush piling, and he said to me in effect: "It is costing the Government an awful lot of money for fire protection in this little gulch. I'll get about 150,000 ties and 3 million feet of logs on this job. I am paying my tie makers 2 cents a tie for brush piling, and the brush from the saw timber will cost at least 50 cents a thousand to pile. That figures out about $4,500 for this one little gulch of about 900 acres. Any time you want to cut out the brush piling I will pay you 2 cents a tie more for the timber, and you will save the cost of burning the brush in addition."

This brings the question home to the Forest Service in a very definite manner: Are we justified in expending such a large percentage of our stumpage receipts for fire protection on timber sale areas? The Forest Service records for the fiscal year 1913 give the average stumpage price for timber sold in District 1 at $2.09 per thousand. Figuring the cost of brush piling and burning at from 40 cents to 50 cents per thousand, this means from 20 to 25 per cent of the stumpage price going into brush disposal.

Statements of the cost of brush piling and burning vary widely with different operators and different classes of timber. J. Alfred Mitchell, in his very interesting discussion in the "Proceedings" for October, 1913, gives the actual average cost in District 5 as 33 cents per thousand for piling and 4.6 cents per thousand for burning, a total of 37.6 cents, though he later assumes that 30 cents for piling and burning is a fair estimate for average conditions. The timber in District 5 will average larger than in District 1, and the cost of brush disposal would probably be less. Records of a large sale of yellow pine on the Bitterroot Forest give a contract cost of 40 cents per thousand for piling and an actual cost of 6 cents for burning. On the Seely Lake sale on the Missoula

Forest brush piling cost on the average 50 cents per thousand. I have no figures on the cost of burning, but it probably costs over 5 cents.

On the Lolo Forest, on three different tie operations, the tie makers are receiving 2 cents per tie for piling brush, which, at 40 ties to the thousand, amounts to 80 cents per thousand.

I believe that on the average operation in District 1 brush piling and burning will cost 40 cents per thousand and probably more.

The timber sold in District 1 in the fiscal year 1913 amounted to 256,000 feet. To pile and burn the brush on this amount of timber at 40 cents per thousand will cost $102,400. The total allotment for fire patrol for the fiscal year 1914 is $109,967—about the same amount for the protection of the entire district as for protective measures, in addition to the regular patrol, on an area of probably 25,000 to 30,000 acres. The Secretary's limitation of annual cut in this district is 1,168,670 feet. When we reach that annual cut, brush piling on the present basis will reach the tidy sum of $467,000 annually.

In determining the necessity for brush piling, the all-important question is: How great is the risk from unburned slashings? If such slashings mean inevitable large fires, the expense is probably justifiable. On the other hand, if it can be demonstrated that large areas of slashings can be reasonably protected by patrol and other measures for a fraction of the cost of brush piling, then it is time to put a stop to an economic waste.

The best way to get at this information is a study of the fire records on areas covered by Forest Service patrol. On the Lolo Forest the largest area of slashing is in the vicinity of St. Regis. Here is the seat of operations of a large lumber company—the Anaconda Copper Mining Company—and two smaller sawmill concerns, besides several independent tie operations. The general region covered by these logging operations includes about 73 square miles, of which about 36 square miles, or one-half, has been cut in the last fifteen years. There has been in the neighborhood of 200,000 feet cut from this area, of which about 100,000 has been cut in the past five years. No measures have been taken to dispose of the slash. The fire risk is considerably greater than on the average Forest Service sale area. Two main-line railroads traverse the area, besides a logging railroad. There are many wagon roads, and a number of ranchers scattered through the woods on partially cleared farms. The Forest Service has covered this area with its usual patrol, no special effort being made to concentrate forces here. The fire records of the Forest show the following fires within this region in the past five years:

Year.	Numer of fires.	Area burned over. Acres.
1908	2	5
1910	9	512
1911	0	0
1912	2	3
1913	1	2½
Total	14	522½

Per cent of total area burned in 5 years, 1.1 per cent.

The only fires of any consequence occurred in the exceptionally dry season of 1910, when there were two fires in the slashings of 200 and 310 acres, respectively. Both were extinguished by the A. C. M. Co., with the help of the Forest Service, at a total cost of $515.

During the same period of five years the records show that 212,000 acres were burned within the boundaries of the Lolo Forest—18 per cent of the total area—against 1.1 per cent of the St. Regis district.

Most of the fire loss on the Forest occurred in 1910, and the records show that the largest fires started in green timber. Very few of them were due to fires originating in slashings.

A careful examination of old slashings shows pretty clearly that with no disposition of the brush the fire risk returns to normal in from 5 to 7 years. Even after the second year, when the needles have all dropped off the branches, the risk is not excessive.

No one uniform method to take the place of piling and burning brush is recommended. The expenditure should be commensurate with the value of the resources involved and the risk of fire after cutting. Under ordinary circumstances, I should say that sufficient protection would be assured by a system of cleared lines 100 feet wide along the main roads and chutes. If there is a logging railroad on the area the strip should be wider—300 to 400 feet. On these lines the brush should all be piled and burned. This would clear up the worst danger points and break the area up into blocks. With lines 100 feet wide, clearing 5 per cent of the area would afford 2½ miles of fire line to the square mile.

Lopping tops may be advisable in some cases, where the brush is especially heavy and the fire risk unusually great. In many cases on steep slopes logging shatters the tops pretty thoroughly and lopping would not be necessary.

Extra patrol of cut-over areas in many places will be desirable, particularly where a large area is involved. On a sale of 50,000 feet, a patrolman four months in the year for five years would cost only 3 cents per thousand feet. It would probably be entirely feasible to have the timber purchaser provide a patrolman during the life of the sale.

In the case of comparatively small sales in isolated districts, in many cases no disposition of the brush whatever should be necessary.

I am informed that in many places in Europe brush burning is considered entirely too great an expense to be justified. T. S. Woolsey, Jr., in a letter to the Forester writes: "It was rather surprising to find that in the Landes, when the branches cannot be disposed of for charcoal, that the expense of brush disposal is considered prohibitive. Since a clear-cutting system is used, the result is a slash. To burn this as we burn our brush would destroy large quantities of seed, and would cut down the profits. In the Landes the brush is no longer dangerous after three or four years. Seeing no 'brush disposal'—as we consider it—in parts of France and Austria has led me to wonder if we have not gone to extremes."

In western white-pine stands, if the present theory of delayed germination of white-pine seed stored up in the ground is correct, then any system of brush burning, even in piles, must destroy a great deal of seed. If the brush is left unburned, it is quite possible that an entire clean cut might be made, depending on the seed in the ground for reproduction. If reproduction failed, it might be necessary to resort to planting. In that case the saving in brush piling would pay the cost of planting several times over.

The greatest point of friction between the Forest Service and the lumberman on timber sales has always been the brush piling. The lumberman feels that it is a useless procedure, involving a cost entirely out of proportion to the benefits derived, and to a certain degree perhaps he is right. The Forest Service has fallen into the way of piling brush just because we always have piled brush, whether it is half a dozen trees cut by a rancher back in the hills somewhere or a big sale of white-pine timber. It is time for us to quit blindly following precedent and at least make a serious investigation of the possibility of less expensive methods of protection.

THE REPLACEMENT OF MOTH-INFESTED OAK STANDS IN NEW ENGLAND

BY JOHN MURDOCH, JR.

Contributed

At the November meeting of the Society of American Foresters, Professor Toumey proposed a method of replacing the dying chestnut stands of southern New England. A problem similar to that in Connecticut has for many years been developing in eastern Massachusetts, but only of late has a serious attempt been made to solve it. The apparent solution is in general the same as that proposed by Professor Toumey for his problem, but the underlying principles are far deeper. With the chestnut, the question is one of filling blanks caused by damage cuttings. With the gypsy and browntail moths, the future work will be improvement cuttings, with the moths considered as the most important factor; at present, damage cuttings are also necessary in many of the worst infested places.

Beginning in 1908, the annual reports of the Massachusetts superintendent for suppressing gypsy and browntail moths, and of his successor, the State Forester, have called attention to the relative immunity to these insects of pure stands of pine, and have suggested the possibility of improving conditions with regard to the pest by the practice of better forestry. For a number of years the principal efforts were directed to the removal of weed trees and of inferior specimens, leaving the main stand to be treated by creosoting and spraying. This, however, is too expensive to be practical in forest land proper, although it is effective on lands which are regarded more in the nature of parks. In the winter of 1912-1913 the first determined effort was made to eliminate the moths entirely from certain tracts of woodland, instead of merely making it easier to treat them there. The methods were inspired by Mr. Rane's observation of European conditions, and more especially by the published observations of W. F. Fiske, of the United States Department of Agriculture. The latter's paper, Circular 164 of the Bureau of Entomology, has not received from foresters in general the attention which it deserves. What has been done in Massachusetts is merely the carrying out of his suggestions. The work has been rendered possible by the cooperation of numerous woodland owners who have furnished the capital necessary for it, each on his own land. The results to date have been excellent.

The facts upon which the treatment is based are as follows: There is but one group of forest trees upon which the gypsy moth can normally develop to a serious degree. This is the genus Quercus. The other species which furnish a favorable food are either cultivated, as the fruit trees and willows, or forest weeds, as the gray birch, wild cherry, and witch-hazel. The conifers are strictly resistant; certain hardwoods, such as the ashes, hickories, and maples, are fully as resistant. Others are intermediate—for instance, basswood, beech, and chestnut—but even on these the gypsy moth is unable to reach dangerous numbers. The same statements hold true in general for the browntail moth. If, then, the oaks and forest weeds can be removed, the resulting stand will be almost completely resistant to the pests.

The word "resistant," as used here, applies to a tree with the following characteristics: In the first place, the foliage is distasteful to the caterpillar, and is not eaten except in case of a shortage of better food. Indeed, on most at least of the conifers the early stages of the gypsy are entirely unable to feed. In the second place, the eating of such foliage has the same effect as partial starvation—it renders the caterpillar liable to the "wilt disease." In localities where the disease is not present, resistant foliage can be eaten without evil results, as was amply demonstrated in the early invasions of the moth in this country. Under abnormal conditions, when the disease has for some reason been lost from a locality, the caterpillars may again become universal feeders. The browntails, unlike the gypsies, are apparently not able to eat the unfavorable species.

In many cases, where the oaks do not form more than 20 to 30 per cent of the stand, their removal amounts to no more than a heavy thinning, or acts as a reproduction cutting for the remaining pine. In many other cases, especially where the oak has been severely stripped for several years, there is a good reproduction of pine, and the removal of the oak releases this. Where the oak forms a large percentage of the stand, it can sometimes be heavily thinned, allowing the scattering pine to reproduce before cutting the rest of the oak, or it may be necessary to cut the oak clean and plant with pine.

The end sought is not the complete extermination of the oak, but its reduction from the exaggerated position it now holds in southern New England to something like its position in European forestry. In New England, following repeated cutting of the once abundant pine forests, the oaks have taken possession of acre after acre of the poorer soils, to which they are not adapted, and on which their growth is slow and their final development poor. Abroad, oak is grown principally on the better forest soils, where it is able to withstand the one or two strippings to which it is occasionally subject before the disease and the parasites succeed in checking an attack of the gypsy moth or other similar pest. In the Austrian State forests, for example, oak forms only about 1 per cent of the stand. The same result will be attained in time if the moths are left to do their work unchecked. The oaks on the poorer soils will be killed, and the land will grow up to birch and brush under which the pine will eventually seed in. The process will be slow, however, and the waste enormous, especially since many of the pines will also be killed by the moths which start on the oaks, and the dead material will remain for many years as a constant source of menace from fire.

It has been found that where the oak to be cut in a thinning amounts to seven cords or over per acre, the work can ordinarily be made to pay for itself. If the trees can mostly be cut with an axe, and the wood does not require too much splitting, an acre can be cut over for not more than $20. The wood can ordinarily be figured at $3 a cord in the pile. If the thinning yields much less than seven cords, it will be either because fewer trees are cut—in which case the cost per cord is higher, since the work is not concentrated—or because the trees are smaller, when they yield less wood for the same amount of work, and the wood is less valuable. In either case the work involves some net expenditure. When the wood from a thinning amounts to much over seven cords, it is generally because the trees are larger, and then the cost of making the wood is higher because of the amount of splitting involved. The larger trees, however, often yield ties, piles, and lumber. The average run of Nos. 1 and 2 ties will net 30 to 35 cents apiece; No. 3 ties might as well be put into wood. Piling will net from 1 cent per running foot for the shorter lengths, when these can be sold, to 2 or 3 cents for 30-foot lengths or better. Lumber is worth from $4.50 per thousand up on the stump, according to the quality. A good stand, then, will much more than pay for the cost of thinning.

For clear cuttings or very heavy thinnings the cost per acre is, of course, higher than for ordinary thinnings. Oak and birch brush 15 to 20 feet high can sometimes be cut for about $12 an acre. This will yield only a cord or two of poor wood, and the net cost may be as high as $10. The work begins to pay for itself at about 10 cords per acre, and above that gives a net return.

The above figures include cutting, splitting, and piling the wood; cutting, hewing, and piling the ties; cutting and trimming the piles and logs, and piling and burning the resulting brush. They do not include cutting any great amount of underbrush. Where much of this is necessary, it adds greatly to the cost.

I must differ with Professor Toumey on the necessity of brush disposal, at least where planting is to follow the cutting. Leaving out of account the fire menace, which even with hardwood brush is high for some years following cutting, and especially for young growth, we must consider the extent to which brush interferes with planting. Any one who has walked across the slash resulting from even a moderate thinning knows how much it hinders progress. After a thinning involving 50 per cent or more of the stand—and such are the thinnings which will normally be followed by planting—the cost of the work will often be nearly doubled. The men must crawl through the tangle; the mattock man must find or make an opening in which to dig each hole; the planter is inconvenienced in setting his trees. If the brush is windrowed, the above difficulties, it is true, are obviated, but the windrows occupy nearly a third of the ground which should be planted. Even if the brush is piled, much more ground is covered than should be, and the fire danger is only partly removed. The brush left after cutting the wood to a 2-inch limit can be piled and burned at a cost of from 25 to 50 cents per cord of wood cut. A large part of this is covered by the saving in planting costs; the balance may be considered as fire insurance. Where it is desired to secure natural reproduction, it may be advisable to leave the brush scattered, but not unless, owing to the location of the tract, the danger from fire is small. This difference of opinion may be due largely to the different conditions encountered. Blighted chestnut would naturally give less brush than the rather scrubby oak of eastern Massachusetts, and would interfere less with the planting. This smaller amount of brush, however, would be proportionately cheaper to burn.

The density of planting must be determined by the number of trees other than oak in the stand. Ordinarily the pine should be spaced 6 by 6 feet in each place planted, whether this be an opening between resistant trees or a clear cutting. If an area which has been clear-cut had some resistant trees, the sprouts from their stumps may, of course, be counted on to form a part of the new growth. The two cleanings advised by Professor Toumey will probably be sufficient, but the cost will be higher than his figure of $3 an acre, since all the oak sprouts must be removed, instead of merely those which are overtopping the pine. Two-year old stock will serve where the work is done in advance of serious damage.

Where, however, the moths have been bad for some years, there is apt to be a heavy growth of grass and weeds, and on such areas transplanted stock must be used. The total cost, then, may run up as high as $15 an acre.

On some lots a modification of the above method has been employed. The stands were practically pure oak, and could most economically have been cut clean. The owners, however, desire to maintain a forest cover. Accordingly, a heavy thinning has been made, removing all the white oaks, which are the worst species, and enough of the others to amount to about half of the original stand. The lots have been underplanted with pine, and the remaining oaks will be sprayed for some years, until the pine is large enough to leave alone. This is not economical, but it is far better than trying to spray the whole stand.

The chestnut blight does not now complicate the problem seriously. In the first place, chestnut is not abundant in the region where the moths are the worst, and has been present only in negligible quantities on any of the lots so far treated. Secondly, the disease is not yet bad in the eastern portion of Massachusetts, and is spreading there much less rapidly than in the States further south. Accordingly, if any diseased trees that may be present are cut out, the others can be left as a portion of the resistant stand, with reasonable certainty of their persisting as long as they may be needed for shelter to the new crop of pine. The same holds true as to the rate of spread of the disease practically throughout Worcester county, which is the approximate western boundary of the present distribution of the gypsy moth. As the moth spreads to the south and west it will enter a region where the disease is worse, and here the two problems will overlap more and more. Any scheme for replacing the diseased chestnut in Connecticut must take into account the danger from the moths. Their rate of spread since the work of suppression was renewed in 1905 shows that within fifty years the whole of Connecticut will probably be infested. Where the diseased chestnut is replaced by pine mixed with oak, then that growth will encounter this new danger before it reaches maturity.

THE CONTROL OF RODENTS IN FIELD SEEDING

BY C. P. WILLIS

Contributed

This paper might be entitled a "Study in Failures," for it describes many methods of rodent control which have been tried by the author and others[1] in Oregon and Washington, and it records for all methods an unfortunate lack of success. Whether the one best way of control will finally be found, or whether rodents will always bar success in seeding, it still is of interest to review our efforts and to point out the present status of the problem. Our failures are as instructive as our successes From them we can build to success, either by reconstructing upon their foundations or by directing our efforts to more promising fields of endeavor. The future must decide whether control of rodents is possible or whether we must depend entirely on planting in our extensive reforestation work. All present indications, however, point to the latter conclusion.

To show the full scope of the problem, the extent to which rodents are present on typical seeding areas, will first be discussed.

THE RODENTS AND THEIR WORK

One of the most detailed studies of a sowing area was made near the Wind River Nursery, on the Columbia Forest, on a site which Dr. Ned Dearborn, of the Biological Survey, classed as comparatively free from rodents. On a tract one-sixth of an acre in size six chipmunks and 15 white-footed mice were trapped in 11 days. Observation of Douglas-fir seedspots on the same tract led to the conclusion that 98 per cent of the damage done was the work of mice.

In the course of the rodent study chipmunks and mice were kept in captivity, and it was found that the former could easily eat 600 and the latter 300 Douglas-fir seeds per day. If the seeding was 1,210 spots per acre and 35 seeds per spot, an acre would have 42,350 seeds sown on it. Ninety mice per acre could eat the bulk of this in one night and have only enough for a light lunch the next night. The seed was exposed to attack for 60 days, for it was slow in germinating. During this period the rodents on the tract theoretically could have eaten 69 times as much seed as was sown.

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[1] For experiments upon which part of this paper is based, the author is indebted to Dr. Ned Dearborn, of the Biological Survey, and to Mr. J. F. Kümmel, Mr. C. R. Tillotson, and other Forest Service men.

The actual facts, however, are not as discouraging as the theory. Where the seed was covered one-half inch deep, 96 per cent of the seed-spots showed strong evidence of attack, usually having the husks of eaten seed plainly visible. With 1½-inch covering, 76 per cent of the spots were attacked. Nevertheless a part of the seed was left even when the spot was badly damaged. Some spots were protected my mouse-proof wire screens. Strangely enough, the total number of plants which came up differed little in protected and unprotected spots, and the spot having most plants was one unprotected. These results are not entirely reliable, however, because the seed was sown in early summer and the germination was so poor that the plants in all cases were few and far between. The rodent damage is better expressed in the number of spots having plants. The 1½-inch sowing was a total failure, but with the lighter covering 40 per cent of the protected and only 29 per cent of the unprotected spots had one or more plants. On this basis the density of the stand of trees was reduced 27 per cent because of the rodent damage to the seed. It should be remembered that this was on an area comparatively free from rodents and protected by the trapping of the animals that were present.

Other areas within a few miles of the Wind River Nursery were studied and proved similar to the one above described. Thus three strips on one tract showed respectively 82, 86, and 97 per cent of the spots badly damaged. The examination here was made a month and a half after the sowing, and much of the evidence of damage had meanwhile doubtless been obliterated. The figures are, therefore, very conservative.

On the last tract two more strips were sown by means of a tamp, which made holes 3 inches in diameter and 1 inch deep. Counts similar to the above showed 73 and 76 per cent of these attacked. These figures are especially conservative, since only a small number of seeds was sown, and it was therefore very hard to find the few husks in the surrounding litter.

On still another site counts two days after sowing showed 80 to 90 80 to 96, and 91 to 100 per cent of the spots damaged. In these cases the lower figures indicate the per cent of spots having husks of eaten seed visible, while the higher figures include as well the spots which showed only a disturbance of the surface soil—attributed to rodents. These counts are for one-half-inch sowing, and 1½-inch covering in the same place showed 38 to 52 per cent of the spots molested by rodents. The damage here is especially interesting, for the site was burned in May and then poisoned in June by the distribution of wheat, and either the fire or the poisoning should have accomplished the destruction of the rodents.

From the Wind River Nursery, on the Columbia Forest, we may pass to the Mt. Hebo region, on the Siuslaw Forest. Here sowing has been done on a large scale and has been of very doubtful success. Here, too, rodents have been crediteed with a large share of the loss. Intensive experiments to determine the actual damage by mice and chipmunks have been inaugurated by J. F. Kümmel, in charge of planting in District 6. The experiments are not all completed, but nevertheless indicate the extent to which rodents may injure the seeding. On various plots 25 unprotected spots were compared with a similar number of spots screened against rodents. Twelve different plots show an average of 1.620 plants per spot for screened spots, as contrasted with .016 seedlings for unscreened spots. In other words, the rodents destroyed 99 per cent of the good seed in the unprotected spots. Similarly with the number of spots containing plants: for screened spots, 40 per cent had seedlings, as compared with 1.6 per cent for unscreened spots. On this basis the rodent damage reduced the density of the stand of trees 96 per cent. Ten of the twelve spots were upon an area poisoned the summer before sowing. Here is a case, then, where rodents are not supposed to be plentiful and yet have turned to utter failure an otherwise perfect success in seeding.

On the Rock Creek area of the Snoqualmie Forest an experiment similar to the Mt. Hebo one was initiated. Counting only the spots with trees, the average number of plants per spot was 2.6 for protected and 1.7 for unprotected spots. A much greater difference was apparent in the per cent of spots having trees. This was 72 per cent for protected and only 28 per cent for unprotected spots. In other words, the density of the stand was reduced 61 per cent by rodent destruction of the seed.

These results are likewise corroborated by observations east of the Cascade Summit, and particularly by a detailed experiment on the Whitman Forest.

The damage to seeding mentioned has all been attributed to rodents. This probably is not strictly true, for small birds are often active pests and some of the loss can probably be credited to them. Birds, however, take only the seeds upon the surface of the ground, according to my observations. If this be true, they eat very little, for it is only by chance and infrequently that any seeds are left uncovered.

This, then, is the problem: To control the rodents, which, partially checked by poisoning or trapping, may still cause 27 to 96 per cent loss in our seeding. It is only under exceptional conditions at present that we can hope to escape 66 per cent loss from rodents. With seeding at $5 and planting at $8, seeding is uneconomical unless the total loss is reduced below 40 per cent. Considering the misfortunes which assail the tender seedlings in their early years—the damage from drought, from frost, from snow, from fungous diseases—it seems sure that the rodent loss must be cut down to a negligible quantity if seeding is to pay.

METHODS OF CONTROL

A brief summary of the methods of control tested will lead to the proper correlation of the measures hereafter discussed.

Rodents controlled by—

- I. Protecting the seed:
  1. By hiding it or disguising it, so that it will escape notice.
  2. By coating it with an obnoxious or poisonous substance.
  3. By encasing it in a wire screen before sowing.
  4. By screening or otherwise protecting the seedspot after sowing.
- II. Killing the rodents:
  1. By poisoning.

HIDING THE SEED

One of the earliest attempts at protection was the deep covering of the sown seeds. Deep sowing has the great practical disadvantage of causing failure of the seeding on most sites. It probably protects the seed from rodents to some extent, but not adequately. In a Wind River Nursery sowing experiment (above described) 76 per cent of the seedspots were attacked when the seed was covered 1½ inches deep. The covering did not protect from rodents, but it did prevent germination. A mouse under observation in a caged nursery bed detected the presence of seed buried 2½ inches deep and nosed the surface of the spot without, however, digging up the seed.

The next move in the game of hide-and-seek was to defeat the keenness of the mouse's nose by giving him something worth smelling—such as naphthalene or iodoform.

With a captive mouse the following experiment was tried: A box 5 by 6 by 1½ inches was filled with soil, seed was sown in it at a depth of 1¼ inches, and two moth balls (naphthalene, a coal-tar product) were crushed and spread over the surface soil. The first night the box was put into the cage the mouse dug into the earth, but only went to a depth of one-half inch, and therefore did not reach the seed. It seems, however, that he dug because he detected the seed despite the strong odor of naphthalene.

With a different mouse a similar test was made, but in this case one-fourth teaspoonful of iodoform was sprinkled over the surface. In one night the mouse ate 45 per cent of the seed in the box.

With still another mouse the first experiment was exactly repeated except that the naphthalene was placed not on the surface soil but in a layer over the seeds themselves. Approximately 50 per cent of the seeds vanished the first night.

These experiments proved that substances which have an exceedingly strong odor to man do not deaden the smell of seeds to a mouse's nose. It had been observed in field sowing that spots mulched with vegetation showed little damage from rodents. From these facts a beautiful theory was built up, to the effect that a mouse's nose is attuned to a different range of odors than those affecting man, and that consequently the delicate odors of leaves and grass disguise the smell of seed far more effectively than do violent odors. To prove or disprove this theory the following experiment was made:

A nursery bed screen was turned into a cage, so that a mouse could be confined in an area 4 by 12 feet in size. The ground surface so inclosed was divided into 48 areas, 12 inches square, to represent seedspots. Forty-six of these were similarly sown with 30 seeds each, and the seed was in all cases covered one-half inch deep with soil. Various sorts and amounts of vegetation were placed on 36 spots, and 10 spots were left unmulched for comparison. A white-footed mouse was turned into the cage and left for two nights. After this the area was left untouched until the seed remaining had germinated. The results were as follows—for 10 spots with mulch, three-fourths to 1½ inches deep, and for 10 unmulched spots:

Class.	Spots dug into.	Spots with seedlings.	Seedlings per spot.		
	Per cent.	Per cent.	Minimum.	Maximum.	Average.
Mulched	60	50	0	5	1.4
Unmulched	100	40	0	1	.4

Mulch helps to hide the seed from rodents, but it is very far indeed from adequate protection. That it does not effectively disguise the seed's odor appears certain.

It seems simpler to find a needle in a haystack than to hide a Douglas-fir seed in all outdoors. For all practical purposes it may be deemed impossible to conceal field-sown seed from rodents.

COATING THE SEED WITH REPULSIVE OR POISONOUS SUBSTANCES

Hide-and-seek having failed as a game, plans were made for an April Fool's Day celebration. "Perfectly good seed" (treated with tincture of red pepper, tannic acid, nux vomica, and other appetizing substances) were fed to mice. A keen sense of humor, however, is necessary to appreciate the joke, for the mice ate the treated seeds with neither a smile nor a grimace, and gave on the whole the impression that they preferred death to the discourtesy of refusing the gifts.

Twenty poisonous and distasteful substances were tested on mice kept captive. This series of experiments was carried out on the Wenatchee Forest by feeding daily to each white-footed mouse 300 Douglas-fir seeds, of which half were untreated and half treated. The substances used and the effectiveness of each are shown in Table 1:

TABLE 1.—*Protective coatings for seeds*.

Substance used in treatment.	Per cent of seed left.	Number of seed left for different mice.			
		Mouse 7.	Mouse 8.	Mouse 9.	Mouse 10.
Zenoleum and sulphur	60	30	56	....	90 *
Zinc chloride	56	0	72	110	....
Iodoform	54	76 *	50 *	....	36 *
Nux vomica	44	60	74	....	5 *
Naphthalene	43	7 *	42	....	78 *
Tincture of iron	19	....	20	....	....
Glycerated asafœtida	14	0	30	....	....
Tannic acid	16	0	....	35	....
Carbolic acid	6	6	....	....	....
Powdered sulphur	2	2	....	....	....
Zenoleum	2	2	....	....	....
Tobacco solution	1	1	....	....	....
Copper sulphate	1	1	....	....	....
Lime and sulphur	0	0	....	....	....
Borax	0	0	....	....	....
Glycerine soap	0	0	....	....	....
Mercuric chloride	0	....	0	....	....
Belladonna	0	0	....	....	....
Tincture red pepper	0	....	0 *	....	....
Quinine	0	0 *	....	....	....

NOTE.—The "seed left" were those which had good kernels—hollow seed were not counted. Where the star (*) is not given, there were 105 good seed among the 150 fed. There were 97 good seed among the 150 in the cases designated by a star.

The table shows a variety of drugs, surprisingly ineffective as protective agents. More striking still is the fact that in the course of the experiment not a mouse died from the poisoning. When the number and kind of substances tested on mouse 7 are noted from Table 1, the force of this statement will be apparent.

The five best substances were tried on three mice and had from 40 to 60 per cent protective value. For reference these substances may be classified as follows:

Zenoleum is a sheep dip and is probably an impure carbolic solution, though it may possibly be a product of wood distillation. It is a dark colored, strong odored, oily fluid. The seeds were dipped in this and enough powdered (washed) sulphur was added to give each a coat of a pasty consistency. The surplus sulphur was disposed of by shaking the seed on a fine mesh screen. The seeds were then ready for feeding.

Zinc chloride was used in the customary commercial powder form. Three parts of water were added to one of salt. The seeds were soaked one hour in the solution and dried before feeding.

Iodoform, powder form, was applied by wetting the seeds and mixing in enough iodoform to give each seed a good coat. The seeds were then dried.

Nux vomica is a drug with strychnine as its active force. Tincture of nux vomica, containing 1 per cent strychnine, was employed. The seeds were dipped in the fluid and dried.

Naphthalene, one of the lighter fractions of coal-tar creosote, was purchased in the form of "moth balls." It was applied by heating at a low temperature until it liquefied, when the seeds were placed in the fluid. The naphthalene was then allowed to cool rapidly, and as it solidified a thin film was deposited on each seed.

The Wenatchee tests were deemed very severe for three reasons: the mice were underfed; they were confined to a small space; they could more easily reach the treated than the untreated seed, because of the position in which it was placed in their cages.

Tests similar to the Wenatchee ones were carried on at the Wind River Nursery, with rather contradictory results.

Zinc chloride, which was next to the best substance tried on the Wenatchee Forest, failed absolutely. Two tests were made with different mice, and in each case all the treated seed was eaten.

Iodoform, the third best substance formerly, was not used in the same form as previously, but in the way it was used it failed. The iodoform test mentioned in connection with the smelling powers of mice proved that the odor of this substance does not disguise the smell of seeds.

Naphthalene, fifth best on the Wenatchee Forest, was tried in the same form as iodoform, and failed to protect the seed as it did when it was used as a seed coating.

At the Wind River Nursery the tests were made more and more severe by putting on the seeds larger quantities of poison, first through mixing the poison into a flour or starch paste, and later by making the paste so thick that a pellet of poisoned paste surrounded the seed.

Nux vomica, iodoform, starch, and flour were made into a pellet three-eighths to one-half inch in diameter, enclosing 10 seeds, but even this proved ineffective. Of 6 pellets, 2 used with each of 3 mice, 3 were nibbled, 1 broken to pieces and the seed in it eaten, and 2 were left untouched.

Of a number of other pellets and pastes tried, only one form of one mixture gave satisfactory results. This was a pellet composed of equal parts of tannic acid powder, tincture of red pepper, and tincture of belladonna, and enough flour to make a thick paste. The pellets were used twice with one mouse, once with two other mice, and once with two different chipmunks, and in every case formed perfect protection. The seed could hardly be sown in such form, however, since it would undoubtedly take too long to germinate, so this substance is not of practical value. The same mixture in paste form gave only 50 per cent value, failing absolutely in one of two cases. The omission of any one of the poisons nullified the protective value of the pellet form.

At the Wind River Nursery the tests were especially severe, for the aim was to find a substance which would protect absolutely, no matter how hungry the rodent was. For this reason untreated seeds were fed only on alternate days, when treated seeds were not tested. There is some question as to the need for such severe tests. It is possible that field trials will be a better means for further experimenting. In other words, a substance which failed in severe cage tests might still prove valuable on sowing areas, where the rodents are not necessarily forced to eat the treated seed or starve. A man might relish "sole-leather soup" if starving, and yet scorn "fried sole" under normal conditions, and a rodent's likes and dislikes also doubtless vary according to his need for food.

SOWING THE SEED ENCASED IN SCREEN WIRE

This method is so new and strange that it may appear laughable. Nevertheless, it was carefully thought out, and was the logical next step when poisonous coating failed. The idea was to have an "armoured pellet," which would protect the seed from all the gnawing of all the rodents on all the seeding sites, come what might.

Pieces of window-screen wire 1 inch wide were rolled into cylinders 1 inch high and one-third inch in diameter. The seeds were placed in the center of the cylinder by first dipping one end in thick mud, then pouring in the required amount of seed, and finally plugging the open end of the cylinder with mud.

It was at first thought that this method of protecting seed would be too expensive for common use, but methods of rolling the cylinders and filling them were experimented with until it was proved that it would be cheaper to sow by this method than by ordinary seed-spotting.

Tests were made with mice confined in small cages, and it appeared that the seed was effectually protected by the wire when a double thickness was used. The method was then further tested by using a mouse-proof nursery bed marked off into "seed spots," as already described in connection with the mulching test. Forty-six of these seed spots were sown by different methods. In some spots the seed was sown in wire cylinders. Other points of difference between the various spots were in the number of seed sown, the depth of covering, and the degree of firming the soil.

After two mice had been turned into the area and left for a couple of days, they were removed and the seed spots carefully examined. Then germination was awaited, and final results obtained.

It was found that encasing the seed in screen-wire cylinders was not efficient protection under the severe conditions of the test. Many of the cylinders were dug from the ground and carried to a corner to be investigated at the convenience of the mouse. Others were exposed by the mouse digging around them, and in two instances seed was extracted from them by the mouse gnawing the top of the cylinder and reaching the seed in this way without digging up the cylinders. Whether the seed in the screens would have been undisturbed under ordinary field conditions is problematical.

There is, however, an objection to the wire cylinder which makes it unwise to spend much time in testing it. The plan in mind when the seed was so sown was to have the root go vertically down and the stem straight up, and so have both miss the meshes of the screen. In this case the wire would rust and fall to pieces before it could hinder the tree's growth. The plants which did grow from the cylinders, however, were reluctant to conform to the plan, and often pierced the meshes both with root and stem. I believe that in such cases the constriction of the wire would injure or kill the plant, though of this I am not certain.

In the mouse-proof nursery-bed test, the ordinary method of seed-spotting, 30 seeds to the spot, one-half inch covering of soil, either firmed or loose, was as successful as any other method, though it suffered greatly from rodent damage. It was, of course, peculiarly consoling to return safely to the starting-point of the whole study.

PROTECTING THE SEED SPOT

It may be noted, in passing, that rodents can be effectively excluded from seedspots by means of wire cones 8 inches in diameter and 8 inches high, sunk 2 inches in the ground. These have given perfect protection in experiments, but they are too expensive for use in large-scale work. With 8 by 8 feet spacing, they cost $40 per acre. They could, of course, be used repeatedly, but even in this event they would be far too costly to be seriously considered.

There is some possibility that a modification of the screening method, cheap enough and effective enough for ordinary use, may yet be devised.

Adequate protection was secured when seed spots were covered with flat pieces of tar-roofing paper. In one experiment some spots were unprotected, others covered with wire screens, and the remaining ones protected with roofing paper, 6 by 12 inches in size in some cases and 12 inches square in others. The germination May 9 was as follows:

	No. of plants per spot.	Per cent of spots with plants.
Unprotected	.04	4
Wire screens	.84	32
Tar paper 6 by 12 inches	1.30	60
Tar paper 12 by 12 inches	3.90	80

The black paper evidently became hot enough to stimulate germination and still maintained proper moisture conditions in the underlying soil. Though the seedlings started so excellently under the roofing paper, there was a high death rate when the paper was removed. I am inclined to think that further experiments will show that the protection and stimulation of the tar paper can be secured without the subsequent loss, which seems due to the sudden exposure of the tender plants. If the paper was removed just as the plants were piercing the surface soil, or removed in very cool, wet weather, or first tilted up to admit light and still afford some protection and removed a couple of weeks later—in any of these cases I think the plants would suffer little in the change from "hothouse" to normal conditions.

On June 12, after the great loss of plants in the tar-paper spots, the conditions were as follows:

	No. of plants per spot.	Per cent of spots with plants.
Unprotected	.50	29
Wire screens	2.50	60
Tar paper 6 by 12 inches	.90	60
Tar paper 12 by 12 inches	1.20	40

The protection of spots with tar paper should be further investigated, for it is the most promising field opened up by the rodent study. In all future trials the paper should be flattened close against the ground by piling earth along the edges. Unless this is done the rodents are sure to burrow under the paper and destroy a good many seeds. In the experiment above described it was clear that the mice detected the seeds under the paper and tried to get them, but were usually prevented from reaching them by the nature and position of the cover.

POISONING THE RODENTS

The control of rodents by poisoning the animals wholesale on our sowing areas does not appeal to me personally, because I think greater difficulties are encountered with this method than with any other. In the first place, it is an acknowledged fact that the rodents do not consider poisoned grain a tempting diet. It is necessary to poison before seeding, because the animals eat tree seed in preference to the grain. If they prefer tree seed they probably prefer also various natural foods, such as insects, berries, and seeds of herbs and grasses. Unless this natural food is scarce the rodents doubtless shun the poisoned grain. This is the first difficulty—to make the rodents relish their poison.

Many rodents doubtless die from the poisoned grain—this, of course, is not questioned. Admitting this, it may be reasoned that we now have partial success in killing the animals and, therefore, may hope for complete success if we perfect our methods of poisoning. This, however, is a fallacy. In our nurseries poisoning has been tried repeatedly and with great care and has nevertheless met with failure. Here it is found that after poisoned wheat has been used for a time the rodents avoid it. If a change is made to barley quite a few animals may be killed by it for a while, but thereafter few eat it. This shows one way in which poisoning is doomed to failure. Not only do rodents shun the grain when natural foods abound, but they even become educated to its dangerous qualities. No high order of intelligence need be granted to rodents to explain their education. If a mouse eats only a single strychnine-treated kernel of wheat, he doubtless falls heir to a severe stomach ache. We do not know how many kernels are necessary to kill a mouse, but five is the number usually assumed. If the rodent has a stomach ache accompanying the first kernel, he may not feel exactly in the mood for four additional grains. Should he be slightly poisoned two or three times he doubtless will hate the sight of the grain. The second difficulty, then, is to make each rodent eat his full share of poison.

Rodents ordinarily are so abundant that killing half or two-thirds or three-quarters of them is but a waste of time, so far as the protection of the sowing is concerned. It has already been shown that on one area, where the mice were comparatively scarce, they yet were capable of eating 69 times as much seed as was sown. It is safe to say that 99 per cent of the rodents must usually be killed if really adequate protection is to be given. In view of the facts already brought out, the difficulty of destroying a sufficient number of the rodents will be apparent.

Ordinarily an area is poisoned some time prior to seeding, especially in the case of fall sowing. Mice multiply at such a rapid rate that if two mice are left in June alone in their glory on a 20-acre tract their descendants will doubtless overrun the area in October. This is enough to cause hope to plunge from its pinnacle into the depth of gloom. It is sad to make the gloom blacker; but it should be remembered that the rate of increase of the mice will probably be in proportion to the number of animals poisoned, since the food supply largely governs the increase and food is most abundant when the area is understocked with rodents.

With wholesale poisoning, then, we have these diadvantages: The rodents do not greatly relish the poison in the beginning, and many of them soon learn to recognize its dangers and to avoid it. This makes it hard to kill the animals, and yet to be successful the poisoning must destroy some 99 per cent of the rodents. This is in case seeding follows soon after their destruction. If seeding is delayed, the animals left after the poisoning multiply especially rapidly and speedily regain full possession of the area. In view of these facts, it is easy to understand the failure of the poisoning in the two cases which have been mentioned in preceding pages and which are more fully described hereafter. These two poisoning projects are the only ones upon which the results have been carefully studied. They doubtless are typical of conditions in District 6.

One project was the poisoning of a 25-acre tract near the Wind River Nursery. Conditions were favorable to success because the area had been cleanly burned about a month before it was poisoned, and the fire was supposed to have killed most of the rodent population. The poisoning was done June 15, partly by Dr. Dearborn, of the Biological Survey, and partly under his direct supervision. A bushel of wheat was used on the

25 acres. The grain was placed under logs and in similar protected places and was well distributed over the tract.

On July 27 most of the wheat had disappeared. One dead mouse was found; some kernels half eaten showed rodent work; bird feathers were discovered near piles of the wheat. It was the opinion that small birds had taken most of the grain, but the truth of this could not be determined.

An area in the center of the poisoned tract was sown late in October. Two days after sowing, one count showed 80 per cent of the seedspots surely attacked by rodents and 96 per cent apparently molested. This was near the border of the sowing. In the very center of the poisoned tract a similar count showed 80 and 90 per cent respectively. Other counts made showed 91 and 100 per cent respectively. These counts are for one-half inch sowing. Where the seed was covered 1 inch deep there also was loss, though it was not so marked.

Five mouse traps were set twice. In each case they were examined two days after they were set. In each case four dead mice were found. The fifth trap was defective, but its bait both times was nibbled.

The rodents were thus very numerous and destructive in October, despite the fire of the preceding May and the poisoning in June. This test, therefore, proved conclusively the futility of early summer poisoning on a small tract.

The other poisoned area differed from the one just described in being large and in being poisoned late in the summer. The locality here was Mt. Hebo, on the Siuslaw Forest, and the area poisoned comprised 2,700 acres. Dr. Dearborn examined the Mt. Hebo region and outlined the procedure in poisoning. His recommendations were strictly followed except in the matter of time of poisoning. He had advised early summer for this, but practical difficulties and shortage of money interfered with the plans so that little progress was made until well into August. The poisoning work continued from then almost to the beginning of seeding. About half a bushel of wheat was used for each 30 acres, and the grain was placed in protected places, as in the Wind River poisoning.

Trapping was done in connection with the poisoning, to test the effectiveness of the latter. From the number of mice caught before and after poisoning, it was concluded that 75 to 85 per cent of the rodents had been killed. Mr. Kümmel then planned a series of experiments (referred to above) which aimed to decide with certainty the value of the poisoning. In the fall, two to three months after poisoning, five strips in different parts of the poisoned area were seeded, and for comparison one strip was established on an unpoisoned tract. Each strip had 25 screened and 25 unprotected seedspots. In the following spring the tests were duplicated.

The results showed no difference between the loss on the poisoned tract and that on the unpoisoned area. In this regard, however, the experiment was not conclusive.

In fall sowing, the screened spots had an average of .29 plants per spot and the unprotected spots .026 plants. This means the loss from rodents was 91 per cent. With the number of spots having plants, there was a somewhat smaller difference: 14 per cent of the screened and 2.6 per cent of the unscreened spots had one or more seedlings. On this basis, rodents reduced the stand density 81 per cent. The rodent loss was, therefore, between 81 and 91 per cent, despite the poisoning of the area two or three months prior to seeding.

The spring sowing in protected spots was far more successful than the fall sowing, having ten times as many seeds germinated and five times as many spots with plants. The case was very different with unprotected spots, doubtless because rodents had by this time restocked the area. Only two plants were found in all the 150 unprotected spots, and one of the two was on the unpoisoned area. In spring sowing the loss from rodents was from 99.2 to 99.8 per cent.

With a minimum loss of 81 per cent and a maximum loss of 99.8 per cent, the poisoning must be called a total failure.

SUMMARY

Rodents, and white-footed mice in particular, destroy a large per cent of our field-sown seeds. The rodent loss is so high that it guarantees failure of seeding. Either the rodent must be controlled or seeding must be given up.

Rodents have such keen noses that it is impracticable to hide seed from them by burying it deeply or by disguising its odor.

It is possible that a substance poisonous or distasteful to rodents may yet be found effective for coating seeds. Up to the present no satisfactory coating has been discovered.

Sowing seed encased in screen wire has little to commend it.

Wholesale poisoning of rodents is ineffective. Many, but too few, animals can be poisoned.

Mulching the seedspot has a slightly beneficial effect.

Covering the seedspot with tar-roofing paper has given excellent protection to the seed. This method has disadvantages, however, which need further study.

Complete protection is given by covering the seedspots with a wire cone 8 inches high and 8 inches in diameter, sunk 2 inches deep in the ground, but this is too costly for general use.

It is significant that attempts to render the seed repulsive or poisonous to the rodent have failed; that wholesale poisoning of an area has failed; but that efforts to guard the seedspot have been more successful. It is at this point that the study should be taken up, if it is hereafter continued.

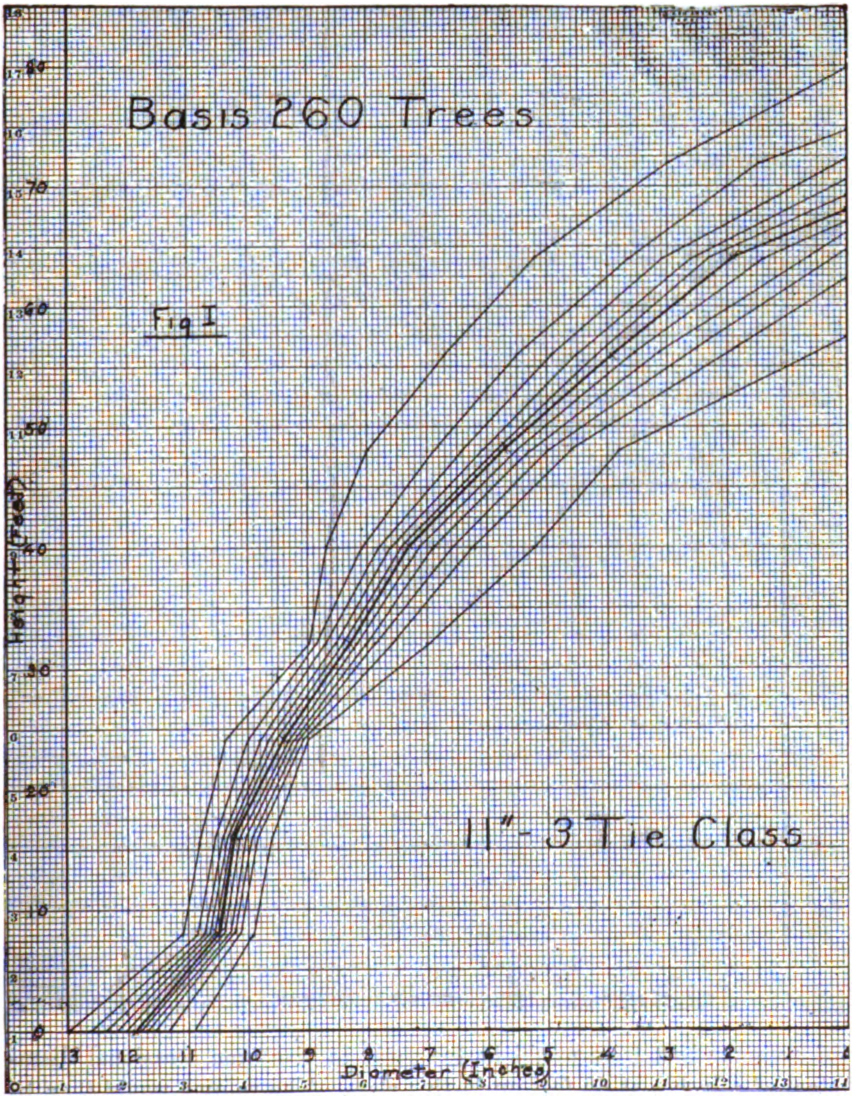
TAPER CURVES IN RELATION TO LINEAR PRODUCTS

BY F. S. BAKER

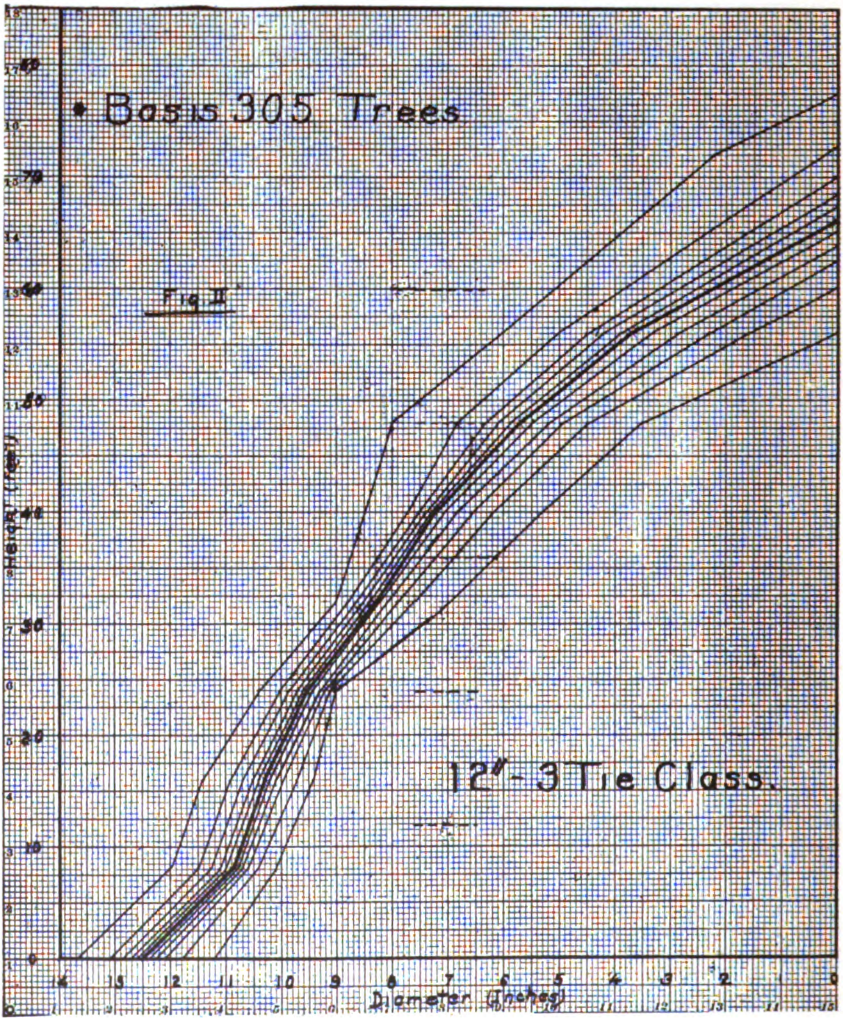
Contributed

In making up two volume tables showing yield of trees in various linear products for lodgepole pine, it was discovered that the methods of volume-table construction showing contents in board measure were not applicable to the construction of tables showing linear products. In consequence of this, a series of curves have been worked out by which volume tables for linear products can easily be derived, and with an accuracy at least equal to tables derived from the original sheets, and with a great deal less time and labor.

In constructing an ordinary board-measure volume table, it is usual to make "taper curves" for each diameter and height or log length class. These curves show the diameter of an average tree in each class from the stump to the top of the tree. The contents of the average tree is then obtained. Thus it may appear from these curves that an average tree of a certain class will contain a log 22.7 feet long cutting to an 8-inch diameter limit. By using log rule curves, it is possible to ascertain the contents of such a tree. This is much simpler than figuring the board contents of each tree separately and then averaging all the trees in each class. Also, taper curves, once made, allow the quick construction of volume tables showing contents to different diameter limits than first contemplated with good accuracy, as well as show the general form of the tree. When, however, it comes to applying these taper curves to the construction of volume tables showing linear products, as ties, props, posts, poles, etc., and especially the very long products, it completely fails to give satisfaction. The values vary so erratically, even when the taper curves are smooth and have a heavy basis, that they cannot be rounded off with anything approaching accuracy. The cause of this is that the average tree as represented by the taper curves is considered as a single tree, and not the composite representative of a widely varying group. A single tree cannot have a fractional part of a linear product, as a telephone pole and a half, for half poles are never cut; hence the average tree will always show a whole number of linear products, fractional products never appearing. One tree can have one and another two, however, and the mean will then have one and a half. The difficulty can be more clearly shown by a concrete illustration. Suppose taper curves show a certain average tree to have a diameter of 8 inches at a point 30 feet above the stump. It is required to find the number of poles 30 feet long, with a top diameter of 8 inches, this class of trees yields, of which this tree is the mean. At the first glance, it will appear that the yield will be one pole exactly. Considering the average tree as the repre-



sentative of a class, however, it will be seen that half the trees in that class were under 8 inches 30 feet up, and half were over 8 inches. The first half made no poles at all; the second half made but one, as the taper of even the best trees would be too great to give even occasional diameters of 8 inches at 60 feet up in this class. The volume would then be one-half a pole instead of one pole, as first appeared, since half made one pole and half made no poles.



Considering another case, using the same tree, suppose the pole were to be 30 feet long, with a 9-inch top. From the taper curve it would seem that the yield would be nothing. The trees that averaged 8 inches at 30 feet up, however, might have ranged from 10 inches to 6 inches. In that case there would be some poles secured from that class of trees.

If the range were 9 inches to 7 inches, it would just fail to yield a pole. In dealing with linear products, then, it is necessary not only to have the taper curves, but also curves on each side showing the limits of the range of diameters. In practice it is also necessary to have other curves showing the range of diameter of small groups of trees that go to make up the class, 10 per cent groups being used in this series of curves.

Figure I shows the series of curves for the 11-inch three-tie class (the height classification being by ties or half logs, as the data was collected for tie tables). The middle, heavy line is the "taper curve" line, as commonly understood, or average tree for the group. The upper line shows the tree with the least taper and greatest height that falls into the group, and the lowest line shows the shortest tree with the most rapid taper. The other lines are so spaced that 10 per cent of all the trees in the group will fall between any two adjacent lines. In this particular group having 260 trees basis, at the 40-foot height, 10 per cent of the trees, or 26, would have a diameter ranging from 8.7 inches to 8.1 inches, 26 would have a diameter between 8.1 inches and 7.8 inches, and so on. If now a question is asked similar to the one before, How many poles 30 feet long with an 8-inch top will be yielded by an average tree of the 11-inch three-tie class? we can at once see that only 10 per cent fail to meet the requirement; 90 per cent do. Hence an average tree will yield 0.9 of a pole. Figuring on the basis of the taper curve alone, one would be the answer, which is not very far different in this particular case. Similar sets of curves have been made for 10-inch to 15-inch diameter classes and one-tie to six-tie height classes, and by finding the yield in each class a full volume table can be prepared. The longer the product is, the greater will be the error arising from the use of a single average taper curve. This is due to the fact that fewer long products can be taken from a tree, and as whole products, not fractional parts, are read from taper curves, the error is greater in proportion. The following table shows the difference in values as read from the average taper curve and the full set of curves, using the 11-inch three-tie class, the products being taken to an 8-inch top limit:

Length of product.	Yield per tree from average taper curve.	Yield per tree from set of curves.	Per cent of error.
40	0	.1	....
30	1.0	.9	+10
20	1.0	1.1	—10
15	2.0	1.9	+ 5
10	3.0	3.0	0
8	4.0	3.8	+ 5
6	5.0	5.3	— 6
5	6.0	6.4	— 6.6
2	17.0	15.9	+ 6.5

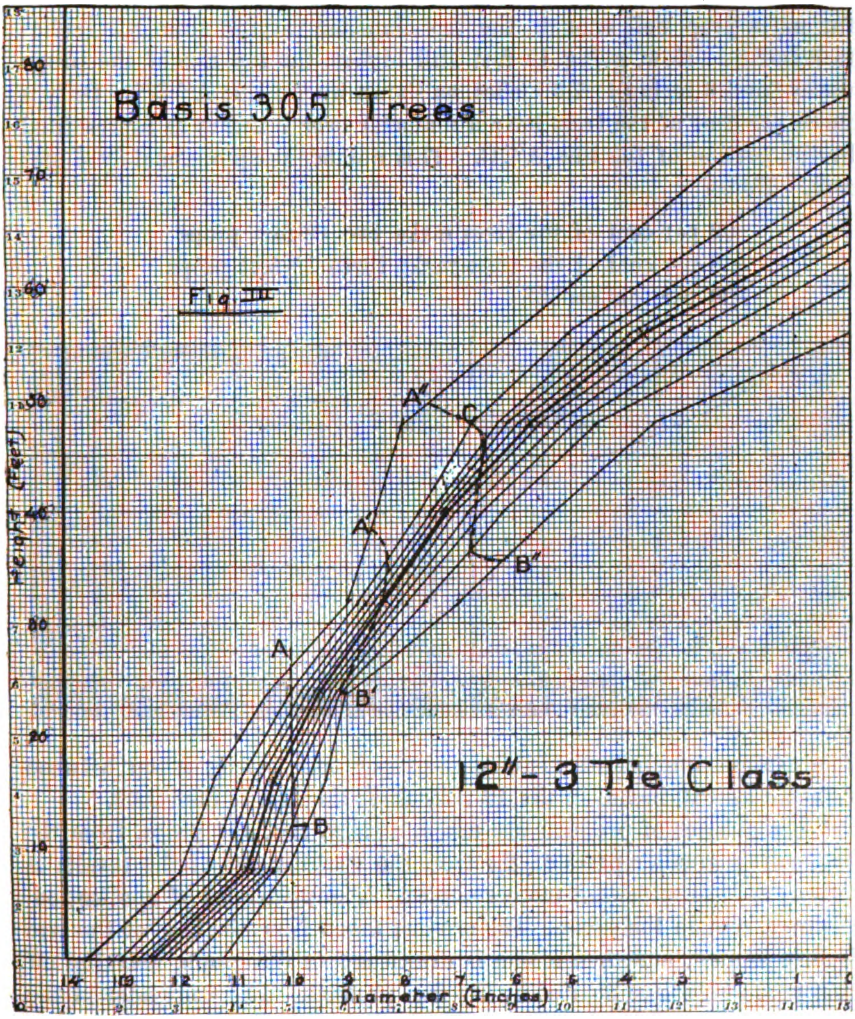
The use of the curves for volume tables is very simple. There are certain differences in procedure, however, according to the specifications of the product. The simplest case, and the one of most frequent occurrence, is when the product is to be cut to a certain top diameter limit, that being the only factor to be considered. Figure II shows how the number of 12-foot props to be yielded by the average tree of the 12-inch three-tie class is obtained, the top diameter limit being 7 inches. It is obvious that all the trees in the class are capable of yielding at least two such props. The 36-foot three-prop line, however, cuts across the series of curves and shows that a part of the trees are of such rapid taper that they are incapable of furnishing over two 12-foot props. Remembering that 10 per cent of the trees lie between any two adjacent lines of the curves, it will be seen that a little over 10 per cent—about 12 per cent—of the trees make only two 12-foot props. The bulk of the trees make three props; for counting the spaces between curves included between the 36-foot and the 48-foot horizontal line and estimating fractions of spaces, 80 per cent will be obtained. The remaining 8 per cent of the trees have a sufficiently small amount of taper to make four 12-foot props. Then:

12 per cent	2 props
80 per cent	3 props
8 per cent	4 props

The average of these figures gives 100 per cent, or 100 trees, yielding 296 props, one tree yielding on the average, consequently, 2.96 props.

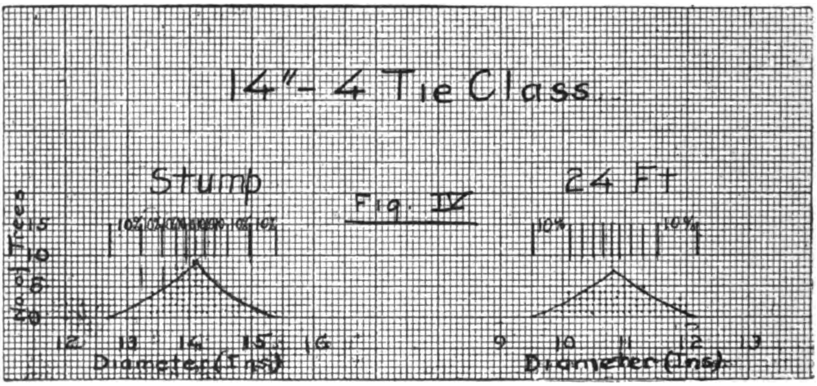
When maximum and minimum top limits both are set for the product, the derivation of the yield of the trees is less simple; but still it is capable of being found by means of these series of curves, whereas by means of single taper curves it would be practically impossible to ascertain the volume at all.

Figure III shows how the number of 12-foot props having a top diameter of 7 to 10 inches would be derived from the 12-inch three-tie class according to the curves. To start with, it is obvious that to get the most out of the tree the largest products that will conform to specifications should first be taken. Hence the line is drawn along the 10-inch line, as 10 inches is the maximum limit. This line cuts the 12-foot height line, however, in the lowest 10 per cent of the trees, showing that if the 10-inch top is rigidly adhered to, some of the props cannot be 12



feet long. To remedy this, the line is bent at right angles along the 12-foot line in the lowest 10 per cent, making the props all at least 12 feet long, but some not up to the maximum top limit. If, now, we go 12 feet farther up, as shown by the line A′ B′, we find that all the trees will furnish a prop well enough, the top diameter varying from 8.3 inches to 9 inches. Now, going 12 feet still higher, the top size of the props varies from 6 inches to 7.5 inches, as shown by the line A″ B″. Only a small per cent of the trees have a diameter over 7 inches as represented by the portion of the line A″ C. This number is approximately 8 per cent. Hence

92 per cent of the trees make two 12-foot props
8 per cent of the trees make three 12-foot props
100 per cent = 208



The average number of 12-inch props per tree having a top between 7 inches and 10 inches in the 12-inch three-tie class is then 2.08.

When a series of products are taken, as logs, ties, and props, from the successively smaller parts of the tree, the working out of the results is slower, as it is somewhat more complex. The principles of application, however, remain the same. The product taken from the base of the tree is first figured, and then a line is drawn across the graph, marking off that part of the tree utilized by the first product. The remainder of the figure is then used in place of the whole, and in just the same way.

Further light upon the use and scope of these curves may be afforded by a description of the method of construction. The original measurement sheets were first sorted out into diameter and number of tie (one-half log) classes, and each class was worked with separately. The first object was to discover how the diameters were concentrated around the average and how widely they ranged. Figure IV shows the arrangement of trees in the 14-inch four-tie class around the mean at the stump and at the section 24 feet above the stump. By repeated trial it was then discovered at what points vertical lines would have to pass through each figure in order to arrange it so that 10 per cent of the trees would be cut off between the lines. These points are indicated in the figure. In making up the curves, it soon became plain that if such methods were pursued an almost endless task would result, with measurements of 2,000 trees to be plotted. By making the top lines of these figures straight and thus giving the figure a triangular shape, however, it was found possible to arrive at a constant relation for the lines, while the error involved by so doing was practically negligible. It was found that if the range of diameters from the mean tree to the extreme tree at any point was *a* inches, then 10 per cent of the trees in that group would have diameters ranging between the mean and the mean plus .1*a*, and hence the first line would come at .1*a* from the line of the mean. The second would come at .21*a*, the third at .36*a*, and the fourth at .56*a*. Consequently, in constructing this series of curves, the mean curve was first drawn in; then the widest deviations were plotted and the other lines were run in between, as determined by the relations stated above.

As to accuracy, they do not necessarily give more accurate values than the values obtained from the original sheets, and when the basis is small they are probably open to quite large errors. If the products are carried to a very small diameter limit in the top, a small error comes into play that was not thought of sufficient weight to impair the value of the curves for general work. In the tops of the trees the mean line does not really have 50 per cent of the trees on each side of it on a horizontal line, as the values spread much more widely from the mean among the short trees than the tall ones, and consequently have more weight. Therefore, there really are over 50 per cent of the trees above the line of the arithmetical mean. Where this was investigated, the number was only 54 per cent to 56 per cent at the 2-inch top-limit line.

These curves have not been in use long enough to fully demonstrate their practical value. The writer prepared a volume table showing volume in ties with an 8-inch face and 7 inches thick as minimum specifications in about two hours as against about ten days, if the 2,000 original sheets upon which these curves are based had been consulted. Beyond being useful for the preparation of volume tables, they promise to assist in determining what size of products and what combinations lead to the best utilization of the trees, while other uses may appear in the future.

FORESTATION A SUCCESS IN THE SAND HILLS OF NEBRASKA

BY SEWARD D. SMITH

Contributed

Probably in no other section of the country is the policy of the Forest Service, which aims to devote the land to its most productive use for the permanent good of the whole people, more clearly exemplified than on the Nebraska National Forest.

The territory which now comprises the Forest was withdrawn from the public domain in 1902, and was later combined with the North Platte reserve. The combined area, three divisions, was slightly in excess of half a million acres. On October 1, 1913, following a classification of lands within its boundaries, the North Platte division was thrown open to entry under the General Land Laws, leaving 208,902 acres which now make up the Forest. The two remaining divisions are situated in the north-central part of the sand hills, of which they comprise approximately 2 per cent by area.

It is not known definitely that the sand hills of Nebraska ever supported a forest cover, but a realization of the need, in this region, of a plentiful supply of timber to meet the demands for fence posts, rough timbers, etc., early prompted the Department to initiate extensive experiments on the Loup division of the Forest. Primarily, the sand hills are adapted to the cattle industry, and from this source the present revenue of the Forest is realized. There are other grazing lands, however, which are more largely sought because they furnish more abundant hay and winter forage. Practically the entire area included within the boundaries of the Forest is composed of a soil so light that cultivation, or even slight overgrazing, exposes it to the mechanical action of the wind and renders it valueless. A consideration of these features, in the earnest belief that tree culture would ameliorate existing conditions, was also instrumental in shaping legislation for a practical demonstration of the principles of forestry, particularly of forestation as a part of agriculture.

The first nursery stock was grown at Halsey in 1903.[1]. For four

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[1] **For a full description of nursery operations at Halsey see Forest Service Bulletin 121, "Forestation in the Sand Hills of Nebraska and Kansas."**

PLATE I

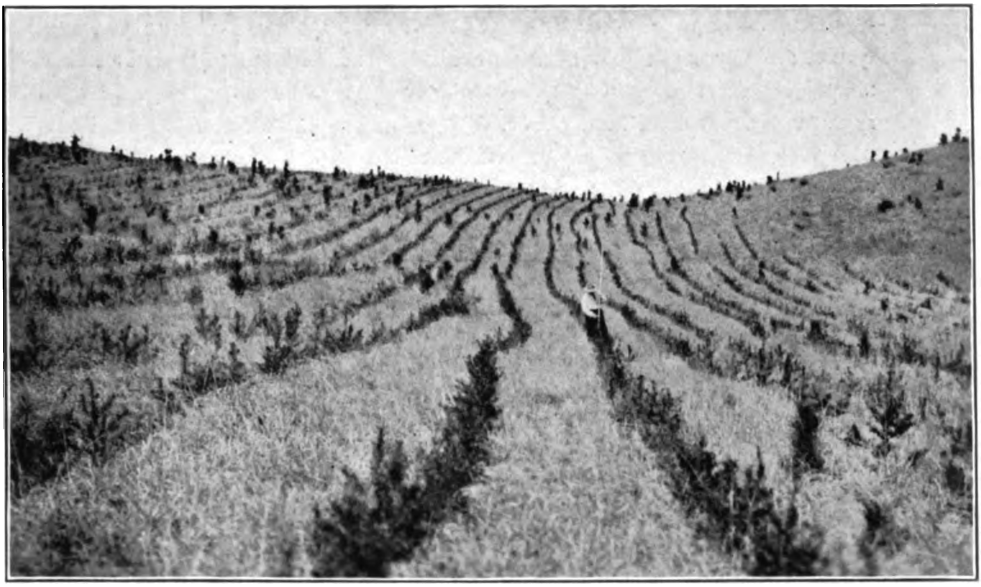

FIG. 1.—PRACTICE VERSUS THEORY. A STAND OF JACK PINE PHOTOGRAPHED THREE YEARS AFTER PLANTING

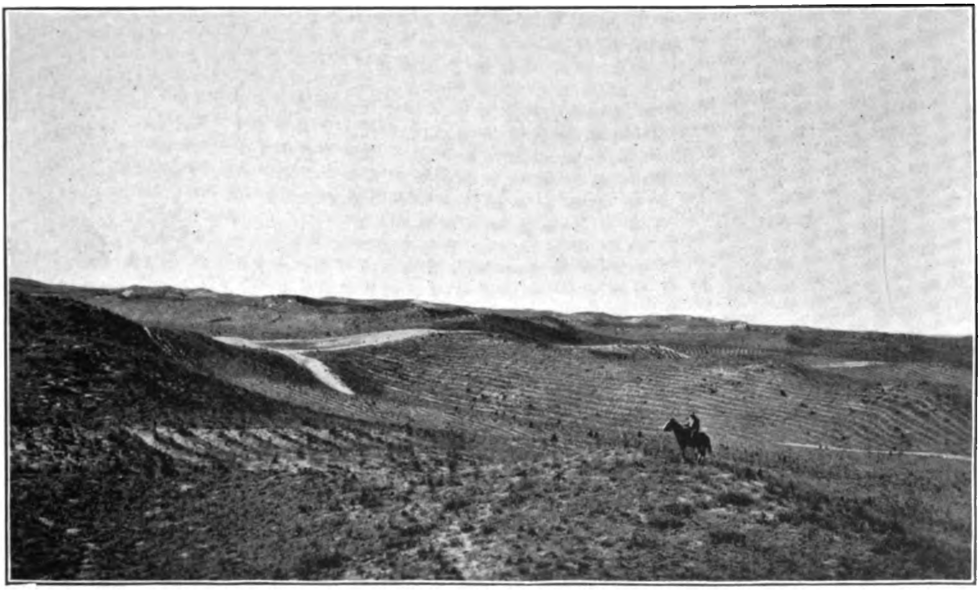

FIG. 2.—IN THE HEART OF THE SAND HILLS. ONE MAY RIDE FOR HOURS WITHOUT SEEING ANY EVIDENCE OF NATURAL FOREST GROWTH

years seedlings only were tried in the hills, but with such discouraging results that transplant stock, locally grown in the nursery, was given a trial, and indicated at once that success would be certain if the trees were properly grown and planted. As a result of this experiment the use of seedlings for general field planting has been discontinued.

The eleven years since the nursery was established have witnessed many changes and improvements, both in field planting and nursery practice. Better stock is produced; more efficient methods and improved equipment have reduced the cost of raising the trees, and the increased survival in the field has added a stability to the work which could be secured in no other way. In the field the trencher method of planting has entirely supplanted the slow and laborious spade method, and as a result of continued experiments the various species of trees are recognized as being specially adapted to particular sites, which makes possible a classification of the area and shows the per cent of each species to be raised yearly. This knowledge has done much to reduce the losses in the field which came from putting the tree on sites where it could not thrive.

The original nursery, which could handle successfully but a few thousand trees, has grown to one of approximately two million annual output. Many improvements have been made. The hand trencher has perfected the work of transplanting, and during the past spring there was worked out a power device for digging the stock for field planting which has reduced the cost of this operation by one-half. The digger, which is operated by a capstan and steel cable, is so arranged that a wedge-shaped cutting edge is drawn under the beds at the desired depth. When the digger is drawn forward the trees are picked from the soil as it breaks over the rear of the wedge. The digger travels at the rate of 6 feet per minute, and with transplants spaced 1½ by 6 inches four men are required to gather the trees.

Nursery and planting operations are handled as separate projects, with the two camps connected by telephone. The success of the planting has won many friends among those who originally maintained a hostile attitude. From this class many desirable laborers are secured. It appears from the past season's work that the labor problem will not be as serious as was once anticipated. During the busy period in April over 90 men were in regular employment. This excludes the local forest officers. Twenty-eight horses, not including four Government teams, were also used for about five weeks. Planting was finished on April 25. The total number of trees planted was slightly in excess of one million, of which 52 per cent were yellow pine, 27 per cent jack pine, and the balance of mixed conifers and hardwoods.

The first field planting was done in 1903, when 70,000 trees gathered from the Minnesota Forest were tried. Because of the change from a relatively moist to a dry climate and because the trees had never been transplanted, the loss was necessarily heavy. Five per cent of the trees are now alive and doing well, as is shown by Table 2. Since 1903 planting has been carried on each year. The earlier records are not as complete as desired, but the estimates of survival, given later on, are believed to be conservative. Many of the areas which were formerly considered failures are making splendid showing, and but very few of the plantations established since 1908 will have to be replanted. It should be understood that the partial failures of the early work were due to using too small stock, to inferior methods of planting, and to delay in putting out the stock. Recognition of this last factor has materially increased the per cent of survival in the field. At the present time every effort is made to get the stock in the ground as soon as the frost is gone. Not infrequently the southern exposures are nearly all planted before the north slopes are open.

A condensed summary of the work to date follows:

Table 1.—*Acreage and results of planting to date on Nebraska Forest*

1903 to 1910, inclusive

Species.	Area (acres).	Proportion living, fall of 1913 (estimated per cent).
Conifers[1]	1,371.82	5–79[2]
Hardwoods	15.06	1
Total	1,386.88	

Planted 1911

		(Actual counts).
Yellow pine	4.5	86.0
Jack pine (Site 1)	18.5	84.0
Jack pine (Site 2)	44.0	73.0
Norway pine[3]	3.0	6.4
Total	70.0	

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[1] Includes 25.4 acres on North Platte division; 14.0 acres on Niobrara division; 6.2 acres Douglas fir and 1.5 acres white fir, planted in 1906, now a complete failure.

[2] Heavy loss due to destruction of 525 acres by prairie fire March 24, 1910.

[3] Forest-pulled seedlings, Minnesota Forest, injured in digging and in transit.

Planted 1912

Species.	Area (acres).	Proportion living, fall of 1913. (Per cent.) (Actual counts.)
Jack pine	32.9	47–73
Yellow pine [4]	85.6	49–69
Norway pine	4.8	26
Scotch pine	1.4	54
Austrian pine	.7	21
Total	125.4	
Planted 1913		
Yellow pine	168.2	61–73
Jack pine	88.0	61–64
Scotch pine [5]	40.6	40–65
Austrian pine	8.8	38–60
Norway pine [5]	2.2	25
Corsican pine [5]	2.1	17
Total	309.9	

[4] Includes 34.0 acres on North Platte division, south slope.

[5] 1-1 stock very small.

The ultimate returns from a forest investment depend, of course, upon the success in planting and the height and volume increment of the individual trees in the plantations. In the following tables there is given a comparison, so far as it is possible to make any, of the growth of the different species. The averages are obtained from 100 representative trees taken in regular sequence in definite rows:

TABLE 2.—*Growth of the plantation of 1903*

Species.[1]	Class.	Slope.	Average height 11 years after planting (feet).	Average d. b. h. (inches).
Jack pine	Forest - pulled seedlings from Minnesota.	Northeast	[2] 12.0	[3] 2.3
Jack pine	Forest - pulled seedlings from Minnesota.	North	10.5	1.5

[1] From 68 trees only.

[2] Maximum height, 15.5 feet.

[3] Maximum d. b. h., 4.2 inches.

Table 3.—*Comparative height of yellow and jack pines*

Species.	Situation.	Year planted.	Class of stock.	Height eight years after planting.	
				Average (feet).	Maximum (feet).
Jack pine......	North slope....	1905	2–0	4.7	8.1
Yellow pine....	West slope.....	1906	2–0	4.5	7.0

Table 4.—*Comparative height of various species planted in 1909*

Species.	Situation.	Class of stock planted.	Height five years after planting.	
			Average (feet).	Maximum (feet).
Jack pine..........	North slope.......	2–1, 3–1	2.9	5.0
Yellow pine........	North slope.......	2–1	1.8	4.2

Table 5.—*Comparative height of various species planted in 1910*

Species.	Situation.	Class of stock planted.	Average height four years after planting (feet.)
Jack pine.............	Bottom	2–1	2.5
Jack pine.............	North slope............	2–1	2.4
Jack pine.............	South slope............	2–1	2.4
Scotch pine...........	Northeast slope.........	2–1	1.4
Yellow pine...........	North slope............	2–1	1.0
Norway pine..........	North slope............	2–2	.9

Table 6.—*Comparative height of various species planted in 1911*

Species.	Situation.	Class of stock.	Average height three years after planting (feet).
Jack pine............	South slope...........	2–1	1.7
Jack pine............	North slope...........	2–1	1.5
Yellow pine..........	South slope and bottom.	2–1	.7
Norway pine.........	South slope and bottom.	Forest-pulled seedlings.	.6

For the first three or four years the height growth of yellow pine is much slower than jack pine, but from present indications it would seem that the jack pine will probably take second place in rate of height growth after a few years.

If the cost of raising and planting the stock were the only consideration, the expense of establishing the plantations would be materially less; but in forestation, as in other lines of agriculture, continual vigilance is the price of success.

The enemies of the plantations are four—birds, rodents, insects, and fire. Grouse sometimes destroy the terminal buds of the transplants in the nursery during the winter season, and since this occurs during the closed season on game birds unusual protective measures must be adopted. Gophers destroy considerable numbers of trees by cutting them off immediately below the surface of the soil. Large trees are taken as readily as small ones. There is little evidence of gopher work until the damage has been done; but systematic poisoning has materially reduced their numbers, and the loss in the spring of 1914 is much less than during previous seasons. The Nantucket pine-tip moth continues to work havoc. Were it not for this pest, it is reasonably certain that the average height of all plantations over four years of age would be increased from 10 to 25 per cent. Very often this insect attacks the second-year transplants in the nursery.

During early spring and late fall, when the grass is dry, there is always danger from fire over the entire forest, and with the enlargement of the plantations and the consequent temporary restrictions on grazing the grass becomes very heavy and the fire menace increases. Fire is by far the worst enemy of the plantation. It is especially dangerous in this section because it may occur at almost any time and because conditions are usually so favorable for its rapid spread. Unless discovered at once it may soon reach beyond control of all human agencies. Lightning may cause fire within the plantation. Forest users may be careless of their matches and cigar stubs; but the greatest source of danger is from fires which start outside the forest, on lands which are being cleared of weeds and old grass in the spring. Sentiment in matters of fire prevention and protection is much more favorable than a few years ago, and the Forest office is always notified in the event of a big prairie fire, even though the forest is in no immediate danger. Except under very unfavorable conditions this makes it possible to start back fires to check the head-fire, but in case of heavy and continuous wind there is little that can be done.

Protection will always be an important feature of the work. The total yearly expense for constructing and maintaining fire-lines will undoubtedly increase for some time, but the cost per acre should decrease. After three years the trees in the plantations are safe from trampling by grazing animals, and grazing must then supplement other protective measures. At the present time 120 acres of the original plantation are under fence and no loss whatever has followed grazing by horses. Surrounding the plantations and at some distance from them is a regular system of fire-lines. Each line is formed by plowing two strips of furrows from 10 to 15 feet wide on either side of a grassy strip, averaging 75 feet in width, which is burned off every two years, and oftener if the grass is dense enough. In 1913, 50 miles of lines, each ten furrows wide, were plowed at a cost of $5.07 per mile. The cost of burning the line approximated $1.50 per mile.

That the work on the Nebraska Forest is an unqualified success is established beyond a doubt. Protection is now of supreme importance, and, if fires are kept out, exceptional conditions only can bring disaster.

Forestation in Nebraska is not limited solely to the production of timber within the Forest. Demonstration and educational work is practiced, and is supplemented by the free distribution of trees to settlers within the Sixth Congressional District of the State. This is authorized under Act of March 4, 1911. The first shipments were made in 1912, when 90 trees were sent to each of 494 applicants. In 1913, 540 applicants were supplied with 350 trees each, and in 1914 the number receiving trees reached 712. Approximately 75 per cent of the stock is conifers, mainly jack and yellow pine; the balance consists of hardwoods. Considerable interest in forest planting has been aroused by this distribution of trees, and, although it is quite impossible in some cases to secure reports on the condition of the trees each year, as the applicants promised, there is evidence that considerable care is maintained by the settlers, both in establishing and caring for the plantations. Reports in the fall of 1913 showed that, of the 1912 stock reported on, 36 per cent was living at the end of the second growing season, and of the 1913 planting 46 per cent had survived the summer. The summer of 1913 was unusually severe, and it is not surprising that the loss is heavy when the trees are planted under most adverse conditions by people who have had no experience in such work.

The financial success of the Nebraska planting is dependent on the rate of growth which is maintained in the future, and it would be interesting indeed to know at what age the plantations could be cut with the maximum profit. Since the oldest plantations are but eleven years of age, it is quite difficult to predict their rate of growth during the next decade; but it is not out of place to attempt to show what may be expected. Figures given in Forest Service Bulletin 121 show that the average height of jack pine eight years after planting is 7.5 feet, and measurements made in the fall of 1913 (see Table 2) on the same area show an average height of 11.2 feet and a maximum of 15.5. This remarkable growth has been made in spite of the ravages of the pine-tip moth. If these figures are platted and a curve drawn through them to 25 years, it indicates that an average height of 40 feet may be expected in that period.

Probably posts, more than any other class of material, will be in demand in the sand-hill region, and the following computed values have been based on the assumption that a 40-foot tree in 25 years will furnish two first-class and one second-class posts, with a stumpage value of 6 and 4 cents each respectively. It now remains to be shown what the actual receipts and expenses will be at the end of 25 years. Assuming that 1,500 trees are planted per acre, and that of these 50 per cent, or 750, will survive, then three posts from each tree, valued at 16 cents, will represent a gross receipt of $120. The cost per acre of establishing the plantation will be $12 as a maximum, with stock and the cost of planting each $4 per thousand. Considerable expense must be incurred each year for protection and supervision. This should not exceed 10 cents per acre. Then the total net receipts per acre at the end of 25 years would be represented by the difference between $120 and $12, at compound interest, for 25 years. From this must also be deducted an annual expense of 10 cents for the same period, figured with compound interest at 3 per cent. At the end of the period the net receipts are $91.28, which is equivalent to an annual income of $2.50, with interest.

These figures are based on the assumption that the entire stand is to be planted to jack pine; but in the future it is probable that not to exceed one-third of the area planted each year will be under this species, the balance being of the more desirable species, such as yellow and Norway pine, which should furnish a fair grade of lumber. At the expiration of 25 years the jack pine could all be removed, with an income in excess of the original cost of establishing the plantation and its subsequent care, thus removing all indebtedness from the remaining two-thirds of the stand, which could be harvested at any time in the future with a handsome profit.

REPLACEMENT OF YELLOW PINE BY LODGEPOLE PINE ON THE PUMICE SOILS OF CENTRAL OREGON

BY THORNTON T. MUNGER

Contributed

INTRODUCTION

In central Oregon, in the drainage basin of the Deschutes River, and chiefly within the Deschutes and Paulina National Forests, is an area of between one and two million acres on which forest conditions are decidedly unique. But two species—western yellow pine, the valuable commercial tree, and lodgepole pine, here a practically worthless weed—compose the forest; yet their silvical requirements are so unusual and their interrelation is so complicated that a most interesting and puzzling ecological problem is presented to the forester who seeks to explain the why and wherefore of their local distribution.

In some parts of this area the stand is absolutely pure yellow pine; in other places it is absolutely pure lodgepole pine; in others it is an harmonious mixture of the two, and elsewhere the two seem to be in violent conflict to occupy the ground. And each of these conditions prevails on areas that are so strikingly similar in their physical conditions that the change in cover type seems to be due not to the physical factors of site alone, but must be ascribed in part to the competition between the species. In this paper it is proposed to describe the local forest conditions as they exist, to discuss the supposed encroachment of the lodgepole pine upon the yellow pine, and to offer an explanation of its causes and processes. First, however, a word of explanation as to the physiography and local site conditions is necessary as a preliminary to the discussion of forest conditions and the local silvical characteristics of the species.

GEOGRAPHIC LOCATION

The region under discussion lies on a plateau at an elevation of a little over 4,000 feet, just east of the eastern base of the Cascade Mountains. A part of this plateau slopes southward to the Klamath watershed, a part toward the interior drainage basin, and a part toward the north. The region of which this paper treats is chiefly within the latter, in the Deschutes drainage basin. Here and there on the plateau are ridges and cinder cones of volcanic origin, some of which are pronounced ranges that rise 2,000 or more feet above the level of the country. Over large areas, however, the level monotony of the country is broken only by a remnant of an extensive lava-sheet, 25 or 50 feet high, or by a cinder cone 100 or 200 feet high. Through the northern part of this plateau flows the Deschutes River, whose three branches come off the Cascades and unite to form the main river. From its headwaters in lakes on the Cascades the river flows northward on a gentle, sustained grade, and is but very slightly entrenched beneath the general level of the country.

Erosion has not been active in this region since the relatively recent last volcanic disturbance, and therefore the topography is chiefly one upbuilt by volcanic activity and not a relief due to erosion.

PHYSIOGRAPHIC TYPES

Three physiographic types may be distinguished in this region—(1) lowland, (2) bench, and (3) slope.

(1) *Lowland*

Along the several branches of the Deschutes River, through the greater part of their length, is a strip of lowland which is occasionally overflowed and upon which the water-table throughout the year is within 2 to 4 feet of the surface. This strip is usually about 200 feet in total width, but occasionally it broadens out to a quarter of a mile. A few patches of this type occur also along seeps and in topographic depressions away from the river.

(2) *Bench*

On each side of the Deschutes River, through much of its course, and reaching back from the river often for several miles, is a strip of flat country, which is very appropriately called "bench," whether it is generically a river bench or not. This bench land is apparently level, though it slopes with the general level of the plateau in several directions. There are two fairly distinct benches—upper bench and lower bench—and often an intermediate one as well. Sometimes the upper bench borders the river lowland directly; more often the lower bench is interposed between. The level of the former is usually at least 20 feet—more often 30—above the water, while the latter is only 6 to 8. The upper bench really marks the general level of the country; relief above it is due to volcanic lava flows which have been superimposed on the plateau, and the slight relief below the bench is due to the erosion of the river. In the vicinity of

Lapine the upper bench is some 6 miles wide and 20 or 30 long, and this seemingly perfectly flat piece of country goes by the name of the Walker Basin. A relatively small amount of country falls within the lower bench subtype.

(3) *Slope*

All the country above the level of the upper bench is classed as "slope," and usually the line between "bench" and "slope" is clearly marked by the change in grade. The cinder cones, the hog-back ridges made by old lava flows, the main slopes of the Cascades and of the Paulina Mountains, all fall in the slope physiographic type.

SOIL

Perhaps the most characteristic feature of this region, and the one that has the most marked effect upon the ecological problem under discussion, is its soil. The whole country is covered with a mantle of buff-colored pure pumice fragments, one-fourth inch to 1 foot in size, which were showered over the country from the volcanic vents on the Cascade and Paulina Mountains. Its depth also varies—in the Walker Basin it is uniformly about 10 feet, while farther south the pumice mantle is perhaps 40 feet deep. On the slopes it is apparently shallower, and in places the underlying lava rock shows through, suggesting that it has been washed off the hillsides into the flats (now benches), which were perhaps under water at the time the pumice was showered over the country. It is undoubtedly a sterile soil, and its texture is so loose that a man sinks 2 or 3 inches in it in walking, as in beach sand. In traveled roads it crumbles into a fine powder and packs when wet. On the lowland type the soil is a little silty and darker colored. Everywhere else it is pure pumice of very uniform quality and condition over large areas.

CLIMATE

The climate of this region is a characteristic continental one, with about 20 inches of precipitation a year, most of which falls in the fall and winter months. The days are bright and hot in summer, but the nights are cold throughout the year. Though from an agricultural standpoint the climate is very severe, it is on the whole favorable to both lodgepole and yellow pine.

SOIL WATER

In the summer time the surface of the pumice soil has the appearance of being excessively dry, and not without reason, for its extremely loose texture, the absence of a real rain for two and a half or three months, the intense insulation and the drying winds, all tend toward its extreme desiccation. On the benches and slopes there is an almost total absence of herbaceous vegetation, and what little bushy growth there is on the naked soil is of a zerophytic type. In this whole region of a million or two acres there is not a drop of surface water in the summer except that in the three branches of the Deschutes River that come off the Cascades, in a single little tributary from the east, issuing from two lakes in the Paulina Mountains, and in a spring that forms a creek a hundred or two yards long. Considering the excessive dryness of the surface and the evident poverty of the vegetation, it is a matter of surprise that where wells have been dug on the high bench in the Walker Basin abundant very cold water has been found at a depth of 10 or 15 feet. It seems probable that on most of this bench type the water-table is at this depth, or a little deeper. The Cascade Mountains on one side and the Paulina Mountains on the other furnish an abundant source for this underground water, which probably gradually seeps toward the Deschutes River from each side.

Even in the dryest part of the year, when four to six inches of the bone-dry pumice is scraped away, the soil beneath shows moisture by its color, and measurements prove that at a foot down the soil has 12 to 16 per cent of water. This suggests that this subsoil water is evaporating into the air without wetting the surface, and at the same time it is undoubtedly cooling the soil very much. In spite of the abundant subsoil water, the surface seems to be physiologically dry to most kinds of vegetation. On the low bench the water-table is much closer to the surface, and the herbage is correspondingly more plentiful. On the slopes the water-table is undoubtedly deeper, but the surface vegetation shows no more signs of drought than that on the upper bench.

THE FOREST

All of this region was originally, and most of it is still, covered with a forest consisting either of lodgepole pine or yellow pine, or both, but, contrary to expectation in a region of this climate and general physical condition, the former is in the majority. The distribution of these species is somewhat as follows:

The lowland type is either open meadow, with willow brush, or pure lodgepole-pine thickets. Rarely is a yellow pine found here. The lower bench is commonly covered with pure lodgepole pine, occasionally with some yellow pine, but always with a characteristic herbaceous ground cover which the upper bench does not have.

The upper-bench type is sometimes pure lodgepole and sometimes predominatingly yellow pine. The characteristic undergrowth is *Kunzia tridentata* or *Ribes* (sp.). It is this alternation between pure lodgepole and the mixed yellow pine and lodgepole that furnishes the puzzling problem in this region. This type is the disputed territory.

The slope type is commonly yellow pine, with here and there some lodgepole pine, up to an altitude of 5,000 to 5,500 feet, where other species, such as Douglas fir, and much more lodgepole, sugar pine, white fir, become prominent, and the yellow pine drops out. In the slope type *Acrtostaphylus manzanita* and *Ceonothus velutinus*, together with *Kunzia tridentata*, characterize the undergrowth.

SILVICAL CHARACTERISTICS OF THE TREE SPECIES

The characteristics of the two pines in this region are not markedly different from those attributed to these trees in other regions, but one or two points deserve especial mention, since they have a bearing on the interrelation of the species. With a soil such as has been described, it is not surprising that the development of both species is very poor, and they show, therefore, that they have a hard struggle to live and develop. Their growth is very slow; their general development is very poor; they are short for their diameter, and are uncommonly defective. The lodgepole pine is particularly poor, it being usually very scrubby, limby, and short.

Although the reproduction of yellow pine in most parts of the State is vigorous, here it is poor. The seedlings seem to have great difficulty in surviving their first year in the loose surface—dry pumice; the few that do survive are those that start on the shady side of bushes or in the well-mulched soil at the bases of big dead trees. Many of the seedlings start from seed that has been buried by a chipmunk (by actual count 85 per cent of the one-year seedlings are in these chipmunk-sown clumps), showing the advantage that is gained by a substantial cover. A decided increase and improvement in yellow-pine reproduction is noticed with an increase in altitude on a uniform slope—due undoubtedly to an increase in surface moisture. On a little hill which had a uniform slope and exposure the yellow-pine reproduction increased fivefold in a rise of approximately 500 feet. This indicates how slight a change in the physical conditions effects a decided change in the trees' reproductive strength.

Lodgepole-pine reproduction is decidedly more vigorous than that of yellow pine; its seed is borne annually in great abundance; the seedlings start readily, and they seem to be hardy. After fire its reproduction is especially prolific. The cones open commonly the year that they ripen, and therefore sealed cones are not here a contributory cause to the abundance of the reproduction. On areas freshly burned over, lodgepole reproduction is exceedingly dense, while on areas exactly similar, but not burned over, there is almost no reproduction. The chemical changes in the surface soil due to the fire seem to promote reproduction, and analyses show that there is a good deal of difference in it after fire. It is a matter of common observation that on the upper bench, if an area does not restock at once after a fire, but little reproduction comes in afterward, even in spite of abundant seed and plenty of openings. Many such openings on "sand flats," as they are called locally, are interspersed through the lodgepole-covered benches.

Neither species is here fast growing, but in early life lodgepole's height growth is decidedly more rapid. It is noticeable that when the two species stand side by side the lodgepole outstrips the yellow pine from the start. Lodgepole's growth, however, is not well sustained, and by the end of its first century it falls off decidedly. If the yellow pine is not then overtopped and suppressed, it forges ahead.

THE EFFECT OF PERIODIC FIRES

One of the very important silvical factors in this region is fire, and, as will be pointed out later, it is apparently an influence which has upset the natural interrelation between the two species. There is hardly an acre in the region that does not show signs of fire, and it is roughly estimated that every area has been burned over periodically on an average once in 30 years. In the pure yellow-pine forest, fire runs on the ground surface, scarring the bases of a few trees, eating out the butt and felling an occasional tree, and killing all the seedlings and a part of the saplings. But when the stand is mixed yellow pine and lodgepole, the fire is apt to be more severe, for the pole thickets carry it to the crowns. Where the forest is pure lodgepole, the fires are still more severe, and occasionally a 40 or 50-acre tract is denuded completely by a crown fire. After a hot fire, lodgepole reproduction usually comes up profusely, so that the next stand is as dense as the original forest; even the best stands, however, are patchy as a result of fire, and defective remnants of the previous generation are usually found mixed with the young growth.

LOCAL DISTRIBUTION OF EACH SPECIES

A very close study of the local silvical characteristics of these two trees and observations of their habits on a great variety of sites point to the conclusion that lodgepole will do well on the lowland and lower bench, fairly well on the upper bench, and poorly on the slope, and that yellow pine will do poorly on the lowland and lower bench, fairly well on the upper bench, and well on the slope.

On the lowland and upper bench type, therefore, lodgepole does so much better than yellow pine that it is able to hold practically undisputedly these moister situations. Lodgepole may be considered to be here the ultimate forest cover, chiefly because no other species is vigorous enough to give it serious opposition.

On the other hand, on the slope physiographic type, yellow pine seems to be the ultimate forest cover, for here lodgepole does but poorly. It may be said that on the slopes the rivalry between the two species is so slight that yellow pine easily holds almost exclusive possession. The slopes, therefore, present no particularly interesting ecological problem. Our interesting problem lies on the upper bench, for here there is a very evident rivalry between the two species for supremacy; for, as was stated above, both do fairly well here.

The present distribution of these two trees on the bench land of this region is most difficult of explanation. In one place the forest for thousands of acres is pure lodgepole. In another place it is a mixed and perfectly normal stand of all-aged yellow pine and lodgepole. In other places are scattered very old pines, with a dense understory of young lodgepoles. In still other situations the lodgepole pine is pure except for an old yellow pine here and there, occasionally yellow-pine saplings or evidences of yellow pines long since dead. The transition from the pure lodgepole pine to the mixed stands is usually at a change in the relative level, the former being found on the lower grade. Thus, in traversing a bench covered with pure lodgepole, if a rise in elevation of perhaps only 2 feet is encountered the higher ground carries some yellow pine. It is remarkable how slight a difference in relative elevation is accompanied by very great differences in the forest cover.

But this distinction does not hold for the whole region; sometimes pure lodgepole covers the highest bench land, and occasionally mixed yellow pine is found on quite low bench land. As a general proposition, however, yellow pine is only on the higher places. It has been suggested that the upper bench is too wet for yellow pine, since the water-table is within 10 or 15 feet of the surface. This can hardly be the case, for it thrives on much wetter ground elsewhere, and in this very region does well on some parts of this same bench.

REASONS FOR BELIEVING THAT LODGEPOLE TENDS TO REPLACE YELLOW PINE

The question that confronts us, then, is: Are certain parts of the upper-bench country foreordained by their physical characteristics to produce lodgepole and nothing but lodgepole, while other areas produce both lodgepole and yellow pine, or is there a progressive encroachment of the lodgepole onto the higher ground on which it is usurping the territory that it should naturally share with yellow pine?

The first conclusion which an observer would reach in passing through the country is that much of the upper-bench land belongs to lodgepole because it is unsuitable to yellow pine, and that the yellow pine is found on the highest ground because it is not adapted to grow elsewhere. But the facts as observed do not bear out this explanation, simple and plausible as it may seem to be.

The facts which upset this explanation and make necessary the finding of another hypothesis are chiefly as follows:

(*a*) Very good yellow pine is found growing and reproducing on situations exactly similar to those which have pure lodgepole.

(*b*) On areas now covered with pure dense lodgepole pine are found occasional yellow-pine snags, charred logs, and stumps, which are evidently the remnant of a yellow-pine stand that formerly occupied the ground.

(*c*) On areas which to all appearance are identical one with another is found every gradation from a harmonious mixture of yellow pine and lodgepole to one of pure lodgepole, with the various intermediate stages which illustrate the aggressiveness of the lodgpole pine and the gradual diminution of yellow pine.

We cannot but conclude, therefore, that both yellow pine and lodgepole pine *can* grow on all this upper-bench country. It might also be said that if there were no lodgepole pine in the country yellow pine would occupy the territory exclusively in a full and uniform stand, and *vice versa* if lodgepole had no competition, it would cover all the upper bench in a pure stand. To produce the kind of forest distribution that we now find in this locality we must still further conclude that during the last few thousands of years there has been a progressive increase in the lodgepole pine—an encroachment by it upon the yellow pine. The factors which have made possible this encroachment, this departure from the ultimate type, will be discussed later.

THE HYPOTHESIS OF THE ENCROACHMENT OF LODGEPOLE

To illustrate just how an encroachment by the lodgepole pine might be effected, it may be convenient to assume a hypothetical case:

Let us take an area of the upper bench which contains a harmonious mixture of yellow pine and lodgepole, in which each is growing and reproducing well enough to maintain its proportion in the forest. Now, suppose periodic surface fires begin to run through the forest about once in every thirty years. Each fire will kill most of the young trees of both species under 4 to 6 inches in diameter, and a few of the larger ones, and fire-scar a great many more. But after each fire the lodgepole reproduction over the whole area is very vigorous, and the yellow pine reproduces rather feebly, because the former is naturally a prolific reproducer after fire and the latter is quite the opposite. When both species start on the same ground simultaneously, every advantage is with the lodgepole during the first few decades, and in this way the reproduction of yellow pine is still further handicapped. After this process has been continued for, let us say, 200 years, there will be left the big yellow pines, over 200 years old, that have survived each fire, straggling middle-aged yellow pines, and old lodgepoles that have chanced to survive the last two or three fires and an understory of saplings that have started since the last fire—*i. e.*, under 30 years old—of lodgepole and yellow pine; principally the former. After two or three more centuries of like conditions, the few big old yellow pines of the original forest will have died either from old age or from the injuries of the repeated fires, and not enough of the middle-aged yellow pines will have survived the fires and the competition with the militant lodgepole to take their places. Thus yellow pine will gradually be burned out of the stand—eliminated from the forest—and its place taken by the irrepressible lodgepole. The resultant effect of this century-slow process is a pure stand of lodgepole, with here and there traces of former yellow pine or occasional stragglers that have not yet been eliminated from the stand. In the whole pumice-soil region every step in this process may be found, and it is this comparison of the several stages of the process on similar situations that furnishes strong evidence of the soundness of the above hypothesis.

FACTORS WHICH HAVE PROMOTED THE CHANGE IN THE FOREST COVER

The fact that a transformation in the forest-cover type is taking place, or has been taking place in the last few centuries—that is, that the present cover is not everywhere the ultimate forest type—implies that some physical conditions have been different during the period. This abnormal condition is fire, which is everywhere, as is well known, a very potent ecological influence. There is every reason to believe, and none to doubt, that forest fires have been more abundant since the Indian occupancy of the region, certainly for some centuries, than they were before, due to the redmen's custom of intentionally firing the woods. This one changeable factor seems to be quite enough to upset the delicate relation between these two species. Without this extraordinary factor of frequent fires, this replacement of yellow pine by lodgepole could not have taken place. Though there is active root and crown competition between the two species, it must not be thought that by sheer competition the lodgepole could crowd out the yellow pine on land where the latter was adapted to grow. Quite the contrary, where conditions are favorable to both species, and fires are not abnormally abundant, yellow pine can, in the long run, undoubtedly hold its own against lodgepole, due principally to its much longer life. Since lodgepole does not seem to reproduce freely on the upper bench without the help of fire, it would have particular difficulty in maintaining itself here were fire eliminated.

In short, therefore, this whole transformation in the forest type is due to the increase in the frequency of forest fires. As contributory causes, the following must be mentioned in order to complete a logical explanation of how this process works out:

1. Especial vigor in the growth and reproductive characteristics of lodgepole and a corresponding weakness in yellow pine, thus lodgepole having the advantage in seed production, seed dissemination, germination after fire, rapidity of early development, and competition for crown and root space.

2. The fires must be severe and thorough, such as they are only when there is considerable lodgepole pine in mixture with the yellow pine.

With the advance of the process and an increase in the proportion of lodgepole pine, the fires are more severe and run more in the crowns, thereby hastening the process just so much by damaging yellow pine and promoting lodgepole.

It is reasonable to assume that the factor which has promoted this encroachment, namely, frequent fires, has had a chance to operate equally on all parts of the upper-bench land, yet the encroachment has not taken place uniformly on all areas where it might be expected. In some places, as was mentioned above, the two species are in harmonious mixture; in other places there is but a straggling amount of yellow pine, and in other places none; but usually the yellow pine is on the higher ground. Two feet difference in relative situation is sometimes enough to make a marked difference in the amount of yellow pine. This fact may seem to be a stumbling-block to the satisfactory explanation of the above process; it is not, however, but rather a corroboration of it. In this locality, as in most semi-arid regions, the equilibrium between various forms of forest cover is very delicate, and an inch or two more or less of rainfall or an increase or decrease in the soil moisture will upset this equilibrium and bring forth a very different form of forest cover. The higher spots on the bench are less favorable to lodgepole (because of less soil moisture) and more favorable to yellow pine, and therefore yellow pine has been able to hold its own and resist the encroachment.

Similarly, on the lower ground lodgepole is more vigorous, and yellow pine less so (due probably to the colder soil), and therefore the process makes the most progress here. It has already been mentioned that on the really high, dry ground—that is, on the slope types—there is but little lodgepole pine and no evidence of its encroachment, simply because here yellow pine reproduction is so good and lodgepole so poor that the former can maintain itself in spite of fires and the competition of the latter. The very low ground—that is, the lowland and lower-bench types—belongs to the lodgepole undisputedly.

ECONOMIC ASPECTS OF THE ENCROACHMENT

How much of the upper bench that now is pure lodgepole was once covered in part with yellow pine, is a question that probably never can be answered. It has been estimated that pure stands of lodgepole cover nine times the area in this region that is really ultimate lodgepole pine land.

What its future will be is also a problem. So far as the present-day foresters are concerned, little can be done to change the composition. Since the cause for the transformation in type is fire, the elimination of fires will naturally restore the natural ecological factors to equilibrium and allow the forest to return to its ultimate mixture; but this is at best a very slow process. In forest management, principles such as the following will tend to favor yellow pine, and they are recommended for use:

1. The absolute prevention of forest fires.
2. Brush scattering, without burning, after cutting operations.
3. Cutting lodgepole to a low diameter limit and yellow pine to a high diameter in mixed stands.
4. Use of yellow pine in all artificial reforestation operations.

FOREST TAXATION IN WASHINGTON

BY FRANK G. MILLER

Contributed

INTRODUCTION

This investigation was undertaken with a view to determining the actual burden of taxation on forest land as compared with that borne by other classes of real estate, the effect of the present system of taxation on the management of forest property, and what remedial legislation should be enacted. As a basis for the investigation a very complete list of the timber owners of the State was compiled, and in the course of the study an effort was made to reach each owner, either through a personal interview or through a circular letter calling for information bearing upon forest taxation. The field work, which covered about five months, though extending over practically every section of the State, was centered in Whatcom, Snohomish, King, Jefferson, Cowlitz, and Pacific counties, west of the Cascade Mountains, and in Yakima, Chelan, and Stevens counties, east of the Cascades. These nine counties are so situated as to afford an opportunity to study varying conditions in all parts of the State as they affect forest taxation.

Replies to the circular letter sent out, interviews with property owners of all classes, tax officials and others, supplemented by a research study of the county and State tax records and of publications on forest taxation, constitute the basis of this report. Owners interviewed or heard from by letter represent upward of three and a quarter million acres, or nearly 55 per cent of the timber land privately owned in the State.

The investigation in Washington was made pursuant to a plan of the Forest Service to make an exhaustive study of the question of forest taxation in the United States, the plan being to make a specific study in a number of different States, each typical of a particular region. Such a study has already been completed in New Hampshire, representing the northeastern forest region, and in Wisconsin as typical of the Lake States, and the reports have been published.

CONCLUSIONS

1. The timber industry is the chief resource of the State, and the timberlands paid about 8.5 per cent of the taxes in 1910. The tax on forest

lands in 1910 was about 40 cents per acre for the State as a whole and about 50 cents per acre for western Washington. The tax per thousand feet, board measure, for the State at large was about 1.2 cents, based upon the estimate of this report.

2. Washington has very probably lost more timber through forest fires than has been cut for lumber. The State now has an excellent fire law, and the appropriation for fire protection is increasing from biennium to biennium, though it is still inadequate. The effort of the State is supplemented by a strong and an efficient patrol maintained by private owners.

3. Property in general is not assessed at its true value, as required by the laws of the State.

4. The attempt made by county assessors to assess property at a certain percentage of the true value—lower than 100 per cent and usually lower than 60 per cent—does not work out accurately in practice.

5. The burden of taxation placed upon the same class of real estate of equal value is not uniform on holdings in the same county or holdings in different counties.

6. Timber land is assessed at more nearly its true value than is agricultural real estate, and city real estate is assessed at more nearly its true value than timber land. Moreover, where sufficient data have been collected to warrant comparisons they show that the actual burden of taxation on timber land is generally greater than on agricultural real estate and less than on city real estate.

7. Though still imperfectly applied, forest tax laws are being carried out with increasing efficiency and uniformity. Taxes on forest property have increased rapidly for several years past. Whether it is overtaxed depends largely on how long it is held. Timber which will be carried for a considerable period of years will bear an undue proportion of taxes, and therefore it must be concluded that it is the system of taxation rather than the amount of taxes which is at fault.

8. The evidence points clearly to a relation between the present tax system and premature cuttings. Taxes have not been any great factor in hastening cutting in the past, but the present system is sure to have a more marked influence in this direction in the future.

9. Much confusion exists among timber owners in regard to a substitute for the present plan of taxing virgin forest land. However, preference is expressed for a dual system which would tax the land annually and the timber when harvested. Owing to the serious difficulties in the way of making this substitute, this report recommends its adoption in part only.

10. Despite a rather high tax on cut-over lands, they are not being abandoned for taxes, even when they are known to have no agricultural value. A large percentage of these lands is restocking naturally. Quite a percentage of owners is now holding for a second crop. A still larger number would do so under remedial tax laws. Undoubtedly a yield tax system would stimulate and encourage reforestation on the part of private capital.

THE TIMBER RESOURCES OF THE STATE

An Estimate of the Stand

Data furnished by the Federal Government, the State land commissioner, county assessors, and cruises of private holdings indicate that the State has upwards of 330 billion feet of merchantable standing timber. The report[1] of the U. S. Commissioner of Corporations estimates the stand at 391 billion feet. In the table below the estimate of the timber private owned is based largely on county cruises as furnished by the county assessors. Usually the county estimates are too low, and, following the practice of many of the county assessors, the county cruises, unless there was good reason for believing them to be correct, were increased by a certain percentage, varying from 10 in one case to 50 in another, though generally it was 20 to 25. In counties where county cruises were not available the estimates are in part based upon private cruises and in part on[2] estimates of the U. S. Geological Survey. There is a large area of cut-over and burned land in the State which contains more or less timber, though it is not assessed as timbered land. In King County, for example, land must cruise at least 400,000 feet to the forty to be classed as timber land. In others it must carry 500,000 feet to the forty. There are possibly a million acres of such land, and the estimated merchantable timber on it is given in the table after the heading "On lands not assessed as timber lands."

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[1] Summary of Report of the Commissioner of Corporations on the Lumber Industry. Part I. Standing Timber.

[2] The Forests of Washington, A Revision of Estimates by Henry Gannett.

Estimated area and amount of merchantable standing timber in Washington

	Area timbered, acres.	Amount, M ft. b. m.	Average per acre, ft. b. m.
In private ownership:			
West of Cascades...............	4,337,786	181,514,660	40,184
East of Cascades...............	1,685,161	12,101,776	7,181
On lands not assessed as timber lands	....	10,000,000	....
Total in private ownership	[4] 6,022,947	203,616,436	[1] 32,145
Owned by Federal Government: [2]			
National Forests................	7,600,000	81,492,000	....
Indian reservations.............	1,694,000	6,100,000	....
National parks.................	126,720	1,475,000	....
Military reservations............	13,981	75,000	....
Unreserved public lands.........	84,000	672,000	....
Total owned by Federal Government	9,518,701	89,814,000	....
Owned by the State [3]...............	....	37,000,000	....
GRAND TOTAL.................	[5] 15,541,648	330,430,436	....

[1] This average does not include the 10,000,000 feet on lands not assessed as timber lands.

[2] Report National Conservation Commission, Volume II, pages 194 and 195.

[3] Estimate by E. A. Ross, State land commissioner.

[4] Exclusive of timber land privately owned in Yakima County.

[5] Exclusive of timber land privately owned in Yakima County and the acreage of timber land owned by the State.

Importance of Lumber Industry

Under normal conditions the timber of Washington is being moved off for lumber, laths, and shingles at the rate of four to five billion feet per year. For several years past the State has ranked first among the States in the Union in the quantity of lumber produced. In this connection the following table, showing the chief resources of Washington for 1909, is of interest as indicating the importance of the lumber industry to the State:

[1] Lumber product, including laths and shingles.......	$68,084,169
[2] Grain crop....................................	40,537,750
[3] Mineral output................................	15,483,886
[4] Fruit crop....................................	15,000,000
[2] Fish product..................................	13,534,010
[2] Dairy product.................................	7,378,579

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[1] Report of the U. S. Department of Commerce and Labor, Bureau of the Census, 1909.

[2] Report of the Washington State Bureau of Statistics and Immigration.

[3] U. S. Geological Survey Reports.

[4] Third Biennial Report of the State Board of Tax Commissioners.

From the above table it will be seen that the timber crop is easily the chief resource of the State. Eighty per cent of the manufactured value of the forest product is put into general circulation through the purchase of labor and supplies, thus remaining within the State. In normal times the lumber industry employs 100,000 men. This number includes those engaged in all branches of manufacture, from the harvesting of the tree to the finished product, but exclusive of those engaged in the transportation of the product to the consumer. Two hundred and thirty million dollars are invested in mill and logging plants, including logging railroads. Probably one-third of the population of the State is supported by the lumber business and its dependent industries. Many of our leading cities and towns are almost solely dependent upon the lumber industry. It has contributed more to the settlement and development of the State than has any other interest.

At the present rate of cutting Washington forests would be exhausted in seventy to eighty years if new growth is disregarded. If new growth is taken account of, this period would be extended somewhat, though just how much is problematical, since the acreage in new crop which will be large enough to cut as the old growth begins to give out is not known. It may be said in passing that the great body of the old timber is in a decadent condition. It is putting on some increment from year to year; but this growth is probably offset by loss through decay and windfalls, so that this old virgin forest is hardly more than holding its own, if that. However, this can hardly be used as an argument for rushing this old timber off, as it is still safe for a number of years. Loss through deterioration on account of age will be slight as compared with loss through waste if the timber is rushed off on a weak market.

If the present annual cut were not to increase, it is possible that the new supply would begin to come on by the time the old is exhausted. But in view of the growing scarcity of timber in other forest regions, it is very probable that the cut will within a few years surpass that of 1906, when it reached the maximum. The cut nearly quadrupled in the seven years from 1899 to 1906. If it should increase at one-half or even one-third this rate in the future, then it is certain that under prevailing methods of handling our forests we have lean years ahead. It is of vital importance to the State as a whole, to those remotely interested in the forests, as well as to those whose money is invested in them, to put the lumber industry on a permanent basis. The National Forests are already under management, and plans are being worked out which will insure continuous crops. It is the hope that the State will inaugurate a comprehensive forest policy which will enable her through purchase greatly to increase her forest holdings, and then put the whole under scientific management.

But any forest policy goes only half way which does not include private holdings. Two primary obstacles stand in the way of the practice of forestry on private holdings—the fire hazard and taxes—neither of which is necessarily insurmountable. These are not the only barriers confronting private forestry, but they are exceedingly important ones, and with them removed the way to the practice of forestry will be opened to a large proportion of privately-owned land.

Importance of Timber Lands for Tax Revenue

The third biennial report of the State board of tax commissioners gives the 1910 assessed valuation of the timber lands of the State as $76,834,095, exclusive of the value of a considerable acreage of unclassified timber lands, such as those in Clarke and Yakima counties. The average tax rate on the assessed value of all property for the State in 1910 was nearly 30 mills. It does not follow that all classes of property were assessed at this average rate, since the rate varies in the different counties and in different districts of the same county. But this investigation would indicate that if this average rate were applied to timber property the results would be approximately correct. It follows, then, that the timber lands of the State paid upward of two and a quarter million dollars in taxes in 1910, or about 8½ per cent of the total of $27,083,980 for all the property of the State.

But the importance of timber lands for tax revenue is seen more clearly in a study of the timber counties, more especially those west of the Cascade Mountains. For example, in Pacific County the assessed value of the timber lands was nearly 37 per cent of the assessed value of all property in 1910. In Jefferson County it was over 47 per cent and in Wahkiakum County over 51 per cent. Much of the outlying territory in the timbered counties, such as school or road districts, is even more dependent upon the forests for tax revenue than these figures would indicate.

From the foregoing the great importance of the forest as a resource to the State is apparent, and it is clear that the State should adopt such measures in the handling of this resource as will insure its perpetuity. Western Washington, with her wonderful possibilities for timber production, in common with the rest of the Pacific Coast region, should eventually take the lead in the application of forest principles.

CLASSIFICATION AND OWNERSHIP OF THE LANDED AREA

The total land area of Washington is 42,803,200 acres, of which 15,713,280 acres lie west of the Cascade Mountains and 27,089,920 acres east of the Cascades. According to a report[8] of the U. S. Geological Survey, 95 per cent of the land in western Washington was originally covered with timber. Three per cent is classed as timberless area, consisting mostly of tide flats and prairie, one per cent as rocky and barren land, and one per cent as mountain meadows. In eastern Washington the same report classes 46 per cent of the land as originally timbered area and 54 per cent as treeless.

Of the total land area of the State approximately 42 per cent, consisting of National Forests, National parks, military and Indian reservations and unappropriated public lands, is held by the Federal Government. On September 30, 1910, the State owned as common school and granted lands a total of 2,083,501 acres. In 1910 there were assessed as privately owned lands, exclusive of town and city lots, 22,148,869 acres.

Agricultural Development

The State is divided by the Cascade Range into two regions having widely different climatic conditions. The east side is characterized by light precipitation, low relative humidity, hot summers, and cold winters; the west side has a heavy precipitation, high relative humidity, and equable temperatures.

Grazing, at first an important industry east of the Cascades, is now, owing to the introduction of dry farming methods and the development of irrigation, rapidly giving way to agriculture. Wheat and fruit are the principal crops. Exclusive of town and city lots, 6,211,567 acres, or nearly 46 per cent of the land privately owned, was assessed in 1910 as improved land.

In western Washington, where nearly all the land was at first covered with a heavy growth of timber, agriculture has developed slowly. Of the 8,549,116 acres outside of city and town lots assessed as privately owned in 1910, only 470,663 acres, or 5½ per cent, was classed as agricultural land and improved pasture. As this part of the State contained a population of 732,291, or over 64 per cent of the total for the State in 1910, there were but 0.64 acre of improved land per capita. Here the home demand for farm produce is far in excess of the local supply, and there is the utmost need that every acre of truly agricultural land shall eventually be used for agricultural purposes. But it is equally important to avoid clearing lands at a heavy expense for agricultural use which have little or no value for this purpose. It is, therefore, eminently opportune that the State, through its Department of Geology, in co-operation with the U. S. Bureau of Soils, is making an exhaustive study of the soils of western Washington to determine which are suitable for agriculture and which are not. This survey is still in progress and the final report of the work, therefore, is not available. However, based upon the information at hand, probably not over 50 per cent of the upward of 8½ million acres in private ownership in western Washington can ever be utilized for any form of agriculture. The remaining portion is best suited for the production of timber and should be devoted permanently to this use.

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[8] The Forests of Washington, a Revision of Estimates by Henry Gannett.

The greater part of the land now under cultivation in the western portion of the State is rich, farm products find a ready market, and agriculture is very profitable. Oats, hay, and potatoes are the principal crops. Dairying and fruit raising are growing industries and pay good returns. With the introduction of improved methods of clearing logged-off lands and the use of power machinery in reducing it to a state of cultivation, agriculture here should develop more rapidly in the future than it has in the past.

CHARACTER AND EXPLOITATION OF THE TIMBER OF THE STATE

The forests of Washington cover the greater portion of the territory west of the Cascades and about 40 per cent of the area east of the Cascades. The timber consists almost entirely of coniferous species. In western Washington it is found in dense stands of mature virgin forests, with the species distributed for the most part in belts corresponding to differences in altitude, or strips adjacent to the water-courses. Douglas fir predominates throughout this region, usually associated with hemlock, and at the higher elevations its place is taken by such subalpine species as amabilis and noble firs, supplanted in turn at still higher elevations by alpine species of no commercial importance. Western red cedar is found in abundance in the bottoms, and Sitka spruce occurs near the coast. The most important commercial species are Douglas fir, western red cedar, Sitka spruce, and western hemlock. Some of the other species having less commercial importance because of inaccessibility due to altitudinal range or because of their scarcity are amabilis fir, grand fir, noble fir, yellow cypress, western white pine, and Engelmann spruce.

In eastern Washington the forests grow in the regions of greater precipitation, which usually correspond to the higher elevations. The timber is composed mainly of open, uneven-aged stands. Western yellow pine is the most prevalent species; but western larch, Douglas fir, western white pine, lodgepole pine, and western red cedar are also found and utilized.

THE SYSTEM OF PROPERTY TAXATION IN VOGUE

Section 1, Article VII, of the constitution of Washington states:

> "All property in the State not exempt under the laws of the United States, or under this constitution, shall be taxed in proportion to its value, to be ascertained according to law. The legislature shall provide by law for an annual tax sufficient, with other sources of revenue, to defray the estimated ordinary expenses of the State for each fiscal year."

Section 2, Article VII, reads:

> "The legislature shall provide by law a uniform and equal rate of assessment and taxation on all property in the State, according to its value in money, and shall prescribe such regulations by general law as shall secure a just valuation for taxation of all property, so that every person and corporation shall pay a tax in proportion to the value of his, her, or its property: *Provided,* That a deduction of debts from credits may be authorized: *Provided further,* That the property of the United States and of the State, counties, school districts, and other municipal corporations, and such other property as the legislature may by general laws provide, shall be exempt from taxation." * * *

It is seen that the State by constitutional provision is committed to the general property tax system in raising revenue—a system which in most civilized countries is antiquated and is nowhere satisfactory. Under this system, whatever the efforts of the tax officials to the contrary, there is a marked disparity in the tax burden borne by different classes of property; tangible property, knowledge of which is easy to gain, bearing a very much greater proportion of taxes than certain kinds of personal property which can be more or less easily concealed. The attempt has been made to remedy this defect by securing a constitutional amendment which would permit the classification by the legislature of property for assessment purposes, thus giving the tax system greater flexibility and enabling the State to enact up-to-date tax laws.

An amendment to this effect submitted to the voters at the November election in 1907 was defeated. While the wording of the amendment was faulty in that it was not sufficiently explicit, the object sought by it was good, and a similar amendment should yet be passed.

An act of the legislature in 1905 created a State board of tax commissioners. The board consists of three members, each appointed by the Governor, confirmed by the Senate. The powers of this commission, at first limited to investigations of the revenue laws of the State and the making of recommendations to the legislature for their improvement, have been enlarged by succeeding legislatures till they have become extended and varied. In its third biennial report, page 6, the commission summarizes its powers and duties as follows: "It has general supervision of assessment and taxation throughout the State and over assessors and county boards of equalization as to their duty under the law."

* * *

One of the most important functions of this board is to determine at what percentage of the actual value various classes of property should be assessed in the different counties. To do this the board visits each county and takes sworn testimony from witnesses as to the actual consideration at which different pieces of property have changed hands within the year. From this testimony and on examination of the tax records the ratio of the assessed to the true value for each parcel of property is ascertained, and from massed totals the average ratios for different classes of property in each county are computed. These ratios being known, the general average ratio for the entire State is determined. With this State average as a basis, the taxable value of the property of the different counties is raised or reduced to conform to it.

It will appear that the State board of tax commissioners is an exceedingly important body, and it has exerted a marked influence on the operation of the State tax system. Through its efforts the work of carrying out the system has been greatly improved. It has secured greater uniformity in the assessment of different classes of property, and the tax burden is more fairly distributed as between the different counties than formerly. Through its work improved tax legislation has been enacted, notably the law placing in the hands of this commission the power of assessing the operating property of railroad, street railroad, and telegraph companies.

The commission is largely responsible for the system of cruising timber inaugurated by the counties, and, as is shown further on in this report, this has an important bearing on the whole matter of timber taxation.

The matter of assessing and collecting the tax is handled by the county unit in all the counties except two where the township organization is found. The work of assessment and valuation is carried out by the county assessor and his deputies for the county unit and by the township assessors under the township organization outside of incorporated cities. The former unit of assessment seems to be the more satisfactory, both in uniformity of results and in economy of labor. The State tax commission has this to say in regard to the township system of assessment in Spokane County: "This has proven disastrous to uniformity in assessment and equality in taxation, as township assessors have vied with each other in their endeavor to dodge both county and State taxes."

In addition to the consolidated State and county levy, each county is divided up into school, road, and other improvement districts, and a special levy made in each district to satisfy the needs for that district each year. According to the revenue laws of the State, "All property shall be assessed at its true and fair value in money. In determining the true and fair value of real or personal property, the assessor shall not adopt a lower or different standard of value, because the same is to serve as a basis of taxation; nor shall he adopt as a criterion of value the price for which the said property would sell at auction; or at a forced sale or in the aggregate with all the property in the town or district; but he shall value each article or description of property by itself and at such sum or price as he believes the same to be fairly worth in money at the time such assessment is made. The true cash value of property shall be the value at which the property would be taken in payment of a just debt from a solvent debtor. In assessing any tract or lot of real property, the value of the land exclusive of improvements shall be determined; also the value of all improvements and structures thereon, and the aggregate value of the property, including all structures or other improvements excluding the value of crops, growing on cultivated lands." It will be seen from the foregoing that the valuation required by law is the true value; but this is not observed in any of the counties in the State, either in theory or practice. The State tax commission does not uphold the provisions of this law, but recommends to the assessors an assessment based upon 60 per cent of the true value. In theory each assessor determines what proportion of the true value of the property to be assessed in his county he shall use, and this percentage usually runs below 60 per cent. That the percentage of the true value at which the assessor actually values the property does not always correspond with the theoretical percentage assumed will appear later on in the report.

TAXATION OF DIFFERENT CLASSES OF REAL ESTATE

Agricultural Lands

The proper assessment of agricultural lands is a very difficult matter, particularly so within recent years, due to the great amount of speculation in farm and other lands in the State. Inasmuch as the sale price is supposed in a large measure to determine the value of the property, and since this has been very unstable on the same kind of property, many of the assessors have established a set price beyond which they will not go in assessing farm property. To illustrate: In a certain county in western Washington good bottom land sells for $150 per acre, and even higher in some cases, but the assessor will not raise the assessment higher than $40 per acre on any land of this character. In another county in eastern Washington lands which may in the future be brought under irrigation are assessed at less than 10 per cent of the price for which they are being sold. In a few of the counties, however, the assessor has no maximum assessed value on farm lands, but figures on a fixed percentage of the sale value. One county assessor adopts the following method in assessing agricultural lands: First a large list of the recent transfers of property giving the legal description and consideration on record is secured, and then the assessor goes around the county meeting the owners of the property on his record and finds out from them whether the consideration named in the record is the actual consideration, and, if so, whether it is an equitable one. From this information he then determines the value to be applied to similar property in each locality visited.

A provision of the laws of 1903 exempts from taxation all fruit trees, except nursery trees, and forest trees artificially grown. This exemption as applied to fruit trees was designed to encourage an infant industry in the State. The assessor places a value on the land at the same rate as neighboring lands which have no orchards growing upon them. The industry has grown beyond the period of experiment, and at the present time orchards are among the most valuable and remunerative properties in the State. The value of the fruit crop for the present year will approximate fifteen millions of dollars, and under present conditions this class of property has a high sale value and yields large return to the owner. Many taxpayers feel that this is an unjust law and should be either repealed or amended. They point out that whereas young orchards which are not producing anything should receive encouragement through tax exemptions, an old producing orchard needs no encouragement along this line and is better able to bear the burden of taxation because of its productive capacity than other crops planted out on the same kind of land. On the whole, the ratio between the assessed value and sale value on agricultural lands is lower than that on city real estate or on timber lands. There are three main reasons why this has come about. In the first place, it is pretty generally recognized by assessors, particularly on the west side of the Cascades, that little, in comparison with the older farming communities, is known about the agricultural value of lands in Washington State. The sale values have not adjusted themselves to correspond to the capitalized income to be derived from such property. Cases are not infrequent where investors will clear during one year's income over 200 per cent of the purchase price of the land, and it is often the case on some so-called agricultural lands that a purchaser is not able to clear 1 per cent per annum on his investment. Secondly, there is a general feeling that the State needs more farmers, particularly in western Washington, and that any one pursuing this line of work needs encouragement. Finally, because in some localities the farmer has a reliable permanent vote and because most county officers are either sensitive to public opinion or else looking to another election for office, they favor the farmer.

City Real Estate

City real estate is probably more easily assessed than any other class of real estate. It is true that great speculation has occurred in this kind of property for several years, but the growth of towns and the enhancement in value of city real estate is something about which the average investor in the State is much better able to judge than concerning the value of agricultural lands. In general, speculation on this class of property is somewhat on the decline, and the sale value now represents more nearly the intrinsic value of the property. For this reason, and because of the greater ease with which information is secured by an assessor, the ratio between the assessed and true values on city real estate is greater than on agricultural land, timber land, cut-over land, or, in fact, any form of real estate, and is nearly equal to that on personal property.

Timber Land

Formerly the general property tax was a very loose system of taxation as applied to timber lands, being administered in the main by men having no particular knowledge of timber or special qualifications for the work. The assessments were based largely upon the taxpayer's declaration, sometimes by the estimate of their cruiser, upon hearsay evidence, and upon hasty examination of a small portion of the timbered area. In most cases the timber and lands were not assessed separately. After the State Tax Commission was created in 1905 an attempt was made by it to induce the county commissioners of the several timbered counties of the State to undertake a uniform system of valuation for timber lands. So far, all except one of the counties west of the Cascades have adopted this scheme of valuation for all or a large part of the standing timber, and some of the counties east of the Cascades are using it for a portion of their timber. Inasmuch as this system carried out in the several counties has certain points of similarity, it has been termed the Washington system of county cruises, and both as a system of valuation and in its influence upon timber-land taxation and ownership, is worthy of mention in considerable detail.

Because of the large size, density, and lack of uniformity in the stands of timber found in many places in western Washington, it was realized that any valuation placed upon an average stand for the county or on an acreage basis would lead to great inequalities in assessment. Stands of fir timber running as high as 150,000 feet b. m. are not uncommon, which at a stumpage value of $2 per thousand would amount to a valuation of $300 per acre. Under the present system of taxation it was therefore essential to secure some kind of inventory of the valuable property to be assessed. The method used by private timber-land owners in this and other heavily forested States was adopted, namely, that of making a cruise of the stand of timber on each legal subdivision of patented land. The plan was to hire men whose training had rendered them expert in timber work to go upon each patented surveyed tract upon which a valuation was to be placed and estimate the quantity, kind, and condition of the timber thereon. Because of the existence of public land surveys in the State, it was possible for a cruiser to go upon a tract of land, and, with the aid of rough surveying instruments, locate the boundaries of each 40-acre tract without the assistance of the owner. With the estimation and valuation of the timber, usually a map was prepared by the cruiser showing the principal topographic features, clearings, burns, etc., and a report accompanied the cruise of each section containing 640 acres which described the character of the land, its cover, accessibility, and the ease with which the timber could be logged, all of which information is put together in book form by the county assessor and made a matter of permanent record.

There is considerable variation in the tax rate, both as between the several counties and in different parts of the same county. The following table will show the tax rate on the timber-land holdings of a certain company in several counties west of the Cascades in the year 1909 and the average tax rate for all classes of property for the same year:

County.	Acres.	Tax rate.	Average tax rate on all classes of property, 1909.
Chehalis	16,424	.0455	.04880
Cowlitz	16,840	.0340	.03378
Island	10.377	.0451	.04302
Jefferson	26,069	.0272	.03395
King	5.881	.0278	.03141
Kitsap	22,210	.0362	.04746
Lewis	4,762	.0321	.03329
Pierce	7,309	.0287	.03359
Skagit	5,912	.0403	.04523
Snohomish	30,373	.0305	.03557
Thurston	1,897	.0329	.03542

Cut-over Lands

The taxation on cut-over lands is a matter which varies considerably in the several counties. In some counties where the cut-over lands have no agricultural value a certain minimum and average valuation per acre has been set by county assessors, and in other counties, where cut-over lands are agricultural, some have established a maximum valuation per acre, and others have no limit to the valuation other than the percentage of assessed to true value assumed by the assessor for the valuation of real property. In Snohomish county, for instance, the minimum valuation placed upon logged-off lands is $2 per acre, and a low average ranges between $3 to $10. In Jefferson county the minimum, as stated by the assessor, is $2.50 per acre and the average ranges between $2.50 and $12 per acre. In Whatcom county the lowest is $2 per acre and the average from $10 to $40 per acre. In King county the following figures are based on the true value: The lowest is $0.25 per acre for poor, rocky cut-over land of little value for reforestation, and the average cut-over land having a true forest soil ranges from $1 to $2.50 per acre. The average for cut-over agricultural lands runs from $2.50 to $20 per acre. The average for Lewis county on lands recently cut-over is $2.50 per acre. In Cowlitz county cut-over lands are valued at from $1 to $6 per acre, with an average of $3 per acre.

Very few of the cut-over lands have been abandoned within recent years. During the hard times eighteen years ago, and for several years following, some of the cut-over lands were abandoned in Chehalis, Clallam, Island, Jefferson, King, Stevens, Whatcom, and other counties, but since that time most of the reverted land has been sold by these counties at good figures. With the old-fashioned methods of logging in vogue at the period of abandonment, much timber was left on the logged-off lands which is merchantable today, and some of these lands have for this reason been taken up for the value which this culled timber has; other of the logged-off lands have been taken up by individuals, either because of their supposed agricultural value or for general speculative purposes. The State has grown in population so rapidly within recent years—having increased 120 per cent in its population between the census of 1900 and 1910—that many people have been induced to speculate in lands which might become of value because of the value which the influx of population or the construction of lines of travel brings to neighboring property. When it is discovered that much of this land possesses a soil which is not well adapted to general agriculture, or that the lines of development are not reaching out in the direction of the property held, the tendency will be to abandon these and other lands of a similar character.

Out of 519 answers from timber-land owners to the question, "Have you ever abandoned cut-over lands because of taxation?" only four replied that they had done so; 441 answered that they had not; two gave doubtful answers, or stated that they had no cut-over lands, and 71 did not answer the question.

Comparison of Taxation on Different Classes of Real Estate

In the following table are given figures collected in the field on the assessed and true values, etc., for timber lands, farm lands, city property, and cut-over lands for several different counties for the year 1910. Each county for which figures are given is designated by a letter. The estimated true value was obtained in the following ways: From actual considerations paid or sworn testimony of those having knowledge of offers made for the property by comparing with property of a similar nature in the locality whose value was known, or by estimates of production, cost of marketing, and price to be obtained at the nearest market point:

Estimated true value, the total tax, and the tax rate for timber land, agricultural real estate, and city real estate, based on the estimated true value in counties A, B, C[1]

County.	Agricultural real estate.			Timber land.			City real estate.		
	Estimated true value.	Total tax.	Tax rate.	Estimated true value.	Total tax.	Tax rate.	Estimated true value.	Total tax.	Tax rate.
A	$193,965	$1,388	0.0072	$859,162	$8,907	0.0104	....	......	......
B	81,000	960	.0118	725,320	8,536	.0118	$29,955	$469	0.0156
C	184,900	1,569	.0085	52,235	417	.0080	221,340	2,642	.0119
Total	$459,865	$3,917	.0083	$1,636,717	$17,860	.0109	$251,295	$3,111	.0124

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[1] With a few exceptions, the figures making up the totals in the different counties are for 1910.

The above table shows that for the various parcels of property in question city real estate bears the heaviest tax burden, timber land next, and agricultural real estate the least. In one case, County C, agricultural real estate bears a slightly greater burden than does timber land, and in County B the tax rate is the same on the two classes of property. However, based upon totals for the three counties, the tax rate on the estimated true values is 0.0083 per cent for agricultural real estate, 0.0109 per cent for timber land, and 0.0124 per cent for city real estate.

TAXATION OF VIRGIN TIMBER

Before and After Appointment of State Tax Commission

The State board of tax commissioners, on organizing in 1905, immediately set about investigating the methods used in assessing timber lands. It was soon found that the appraisement of this class of property for assessment purposes was purely guesswork, resulting in the grossest inequalities of value, the poorest and most out-of-the-way tracts often being assessed at the same value as the best and most accessible. The commission began immediately to advocate a cruise of the timber, and such a cruise has now been made in most of the important timbered counties.

Prior to 1908 the land of the State for assessment purposes had been classified outside of the cities merely as improved and unimproved land. In that year the timber lands were segregated into a third class, except in a few counties, and assessed separately. The few years intervening since the creation of the State tax commission mark an important period in the history of the timber taxation in Washington. Before that time, as has been stated, timber lands in most counties were very loosely and haphazardly assessed, and in general the taxes on this class of property were low. The agitation of the question of timber taxation incident to the making of the county cruises and the segregation of timber lands has resulted in a marked increase in taxes on timber property. This fact is clearly set forth in various tables in other parts of this report, but a few specific examples will be of interest here.

Figures furnished by the county assessor of a county in the western part of the State show that the assessed value of the timber lands of the county for 1908 was more than double that of 1907, as a result of the county cruise which was made in these two years. The assessor states that values for assessment purposes have been materially increased since 1908. The following data were furnished by one of the larger lumber companies in western Washington whose holdings are scattered through several counties:

Year	Average assessed value per acre.	Average tax per acre.
1905	$7.10	0.229
1906	13.44	0.364
1907	17.63	0.522
1908	20.57	0.582
1909	.....	0.675

It will be seen that the taxes on the above holdings have more than trebled in five years.

The manager of another large timber company west of the Cascades, in sworn testimony before the State tax commission, stated that the taxes on his company's holdings nearly doubled in the four years from 1906 to 1909, although 20 per cent of the valuable timber had been cut off during that time and about 10 per cent of the land area had been sold to settlers. Furthermore, he added, logs were decidedly cheaper in 1909 than they were in 1907. The records of the State board of tax commissioners show that the average assessed value of the timber lands of the entire State increased from $4.88 per acre in 1905 to $13.59 in 1910, which is an increase of 178 per cent in six years.

Attitude of Lumbermen

In the questionnaire used in this study, six questions bearing directly upon taxation of virgin timber were included. These questions, and the answers to them, follow:

1.—Do you consider that your timber land is over-assessed?

Answer.	Number.
Yes	265
No	138
Doubtful	54
Tax unequal	22
No answer	61
Total	540

It will be noted that 265 replies, or 49 per cent of the total received, state that timber land is over-assessed, while 184, or 34 per cent, say that timber land is not taxed relatively higher than other classes of property. Complaint is made in 22 replies that taxes are not equitably assessed, the small owners in a few cases contending that they are over-assessed as compared with the large owners, while in a few other cases large holders complain that they are discriminated against by the tax officials, who wish to popularize themselves with their constituency.

Whether timber lands in general are over-assessed depends on how long they are held. According to the report of the State tax commission, the average assessed valuation placed upon timber lands of the State in 1910 was $13.59. This valuation probably does not exceed two-fifths of the true average value of these lands. But since the timber land is assessed annually, it exacts a tax which, in the course of a few years, places a value on the timber holdings beyond which they are capable of attaining.

The argument is made that many of the timber-land owners have come into possession of the present virgin forest at relatively low prices—that the value of stumpage has risen, and will continue to rise, sufficiently to absorb the taxes and still make the investment an inviting one. It is further argued that much of the timber has been bought up by outside capital, and is, therefore, held by parties who do not in any way contribute to the welfare of the State except through taxation, and that the State is entitled to large benefit from this source. But these arguments are not entirely germane, and should not be allowed to cloud the really vital issue—the effect of the present tax system on the matter of a further timber supply.

It has been pointed out that the tax on timber land has increased rapidly in the last few years, and there is strong pressure being brought to bear on tax officials constantly to increase it still further. This pressure will be stronger in the future than it has been in the past, for as additional land is cleared, and in consequence yields less tax revenue, the tendency will be to require the non-cut-over land to make up the difference. The facing of this almost certain increase, together with the annual recurrence of the tax, whatever it is, with no income from the property itself with which to pay it, is going to have the inevitable result of hastening cutting unduly, regardless of the residence of the owner or the price at which he bought, which means enforced waste through the rushing of the timber off on a weak market. In fact, there is now a decided movement in this direction, as is shown by the following:

2.—Has taxation ever hastened the cutting of timber on your holdings?

Answer.	Number.
Yes	**155**
No	**230**
Doubtful	**5**
Will do so if present taxes continue	**73**
Will do so if taxes continue to increase	**10**
Will hasten sale	**8**
No answer	**83**
Total	**564**

It is significant that 155 replies, or over 27 per cent of the total, state that taxes have hastened the cutting of timber in the past, while 83, or nearly 15 per cent, of those replying to this question say that taxation is going to force them to cutting, if present taxes continue or are increased. It is admitted that other causes than taxes, such as interest, the fire risk, the necessity of keeping mill plants supplied, etc., have the effect of hastening cutting. Nevertheless, the foregoing clearly establishes a relation between taxation and premature cutting in this State.

3.—Do you consider the present system of taxing forest land satisfactory?

Answer.	Number.
Yes	118
No	313
Doubtful	39
No answer	62
Total	532

It will be noted that 59 per cent of the replies express dissatisfaction with the present system of taxation, as against 49 per cent of the replies to Question 3, stating that timber land is over-assessed, indicating that it is not so much the amount of taxes as it is the system to which objection is made. Many an owner would hold his timber for a number of years and pay the accumulated tax, with interest, when he harvests his crop, but would be obliged to harvest early where the tax must be paid annually. However, the complaint against the present system is not universal, as is shown by the fact that 118 replies, or 22 per cent of the total, state that it is satisfactory.

4.—If it is not satisfactory, please state why it is not.

Answer.	Number.
Discrimination in taxes	66
Taxes too high	86
Taxes too low	4
Hastens cutting	40
Accessible and inaccessible timber not taxed proportionately	10
Inaccurately cruised	37
Taxes same crop year after year	40
Timber and lands should be taxed separately	6
Owner assumes all the fire risk	6
No answer	231
Total	526

While timber owners express much dissatisfaction with the present system, there is considerable confusion among them in regard to the cause of the complaint, as is indicated in the foregoing table, and still greater confusion relative to the remedy, as the table following will show. That taxes are too high is not necessarily the fault of the system, since any system might give rise to the same complaint.

In 66 replies, or 12½ per cent of the total, objection is made that the present system leads to a great deal of discrimination as between both different classes of property owners and owners of property of the same class. These 66 replies reveal quite a general belief that the present system of taxation favors the farmer as compared with the timber owner.

Perhaps the most valid objection offered to the present system are that it hastens cutting, taxes the same crop year after year, and obliges the owner to assume all the fire risk. These points are elaborated elsewhere in the report.

5.—What changes in the present system would you suggest?

Answer.	Number.
1. None	67
2. No answer	195
3. Not prepared to state	27
4. Doubtful	9
5. Better carrying out of present system	49
6. Single tax	11
7. British Columbia idea	5
8. Income tax	3
9. Tax on timber when cut; none on land	36
10. Heavier tax on ripe timber; penalty for cutting unripe timber	2
11. Nominal annual tax on timber and heavier tax when cut per M	10
12. Exemption on cut-over lands until timber is merchantable	4
13. No tax on timber situated on inaccessible lands until cut	3
14. Tax on lumber when cut where lands are not suitable for agriculture; low tax on cut lands	4
15. Tax land annually and timber when cut	84
16. With young growth, tax the land only, and as waste land	3
17. Higher tax on timbered land than on similar land improved for agricultural purposes	1
18. Limit both per cent of assessed value and tax rate in each county on timber	6
19. Have State or Federal Government ownership of waste forest lands. Have present tax on timber and tax State lands	13

Answer.	Number.
20. State to place tax on timber according to the accessibility, quality, etc., instead of county	**1**
21. An annual tax on land and a tax on timber when manufactured	**1**
22. Each owner to be assessed on his own cruise, same to be one on which he would sell	**1**
Total	**536**

The foregoing table makes it clear that while there is much dissatisfaction with the present system of taxing forest land, there is a great lack of unanimity among timber owners in regard to a suitable substitute. In 11 answers the single-tax idea—that is, a tax on the land only—is advanced as a better system than the present for taxing forest land, while 36 advocate a tax on the timber only, thus exempting the land. In 5 cases the British Columbia idea is preferred. The plan referred to is that in vogue on Crown lands held under lease, where an annual tax called ground rental is assessed on the land, and a royalty at a flat rate per thousand is collected on the timber when cut.

In one case it is proposed that each owner be assessed on his own cruise, the same to be one on which he would sell. This plan ought to secure uniformly true valuations, provided it gave the county or State the option of purchasing the land at the owners' valuation, in case its tax officials thought it too low. This is essentially the plan in operation in parts of Australia, where the State reserves the right to purchase the property at the valuation the owners put on it, plus 10 per cent.

Yield Tax Plan as Applied to Virgin Timber

By far the larger number of replies, 84 in all, express a preference for a dual system which would tax the land annually and levy a tax on the timber when cut. The following table indicates that timber owners could more readily agree upon this plan than upon any other that has yet been proposed. This system is illustrated in yield tax tables 1 and 2 below. Two of the other changes proposed embody essentially this plan. For example, in answer 11 it is suggested that a nominal annual tax be placed on the timber till cut, when a heavier tax would be levied.

In answer 21 it is proposed to tax the land annually and the timber when it is manufactured; but whether the yield tax on the timber is placed on the stumpage or on the manufactured lumber, the principle is the same.

A system of taxation which taxes the land and the timber separately, by laying an annual tax on the land and taxing the timber when cut, is not new, as it is the one in use in most of the leading European countries, having been practiced by some of them for a century or more. There it is recognized that an annual tax is highly desirable as a certain definite revenue for the State, while an annual tax without an income from the property taxed works a hardship on the forest owner. The system in vogue is an attempt to satisfy these opposing interests.

In order to test the sentiment of timber owners of Washington in regard to this system, the question below was submitted to them:

6.—Would a tax upon the land and timber separately be more satisfactory than the present system, the land to be taxed annually and the timber to be exempted from taxation until cut?

Answer.	Number.
Yes	254
No	115
Doubtful	76
No answer	79
Total	524

Of the 524 answers, 254, or over 48 per cent, endorse the plan outlined in the question, while 115, or nearly 21 per cent, do not favor it. This system, as applied to virgin timber, is illustrated by the yield tax schedule tables which follow:

TABLE 1.—*Percentage basis*

Yield tax schedule for Douglas fir in western Washington

Amount of tax per acre on present basis.			Amount of tax per acre, timber to be taxed when cut at a percentage of the stumpage value; land to be taxed annually, interest compounded at 5 per cent.							
Tax on timber and land 50 cents per annum.			On standing timber, yield 50 M. b. f.				On land at 10 cents per annum.		Total tax on timber and land.	
Period, years. (1)	Av. per annum. (2)	For period. (3)	Value per M. For period. (4)	Rate per M. For period. (5)	Tax per acre.		Av. per annum. (8)	For period. (9)	Av. per annum. (10)	For period. (11)
					Av. per annum. (6)	For period. (7)				
				Per cent.						
1–5	$0.55	$2.75	$2.00	2.2	$0.44	$2.20	$0.11	$0.55	$0.55	$2.75
1–10	.63	6.29	3.00	3.3	.49	4.95	.13	1.26	.62	6.21
1–15	.72	10.79	4.00	4.3	.57	8.60	.14	2.16	.71	10.76
1–20	.82	16.54	5.00	5.3	.66	13.25	.16	3.31	.82	16.56
1–25	.95	23.86	6.00	6.4	.77	19.20	.19	4.77	.96	23.97
1–30	1.10	33.22	7.00	7.6	.89	26.60	.22	6.64	1.11	33.24
1–35	1.29	45.16	8.00	9.0	1.03	36.00	.26	9.03	1.29	45.03
1–40	1.51	60.40	9.00	10.7	1.20	48.15	.30	12.08	1.50	60.23
1–45	1.77	79.85	10.00	12.8	1.42	64.00	.35	15.97	1.77	79.97
1–50	2.09	104.67	10.00	16.7	1.67	83.50	.42	20.93	2.09	104.43

TABLE 2.—*Flat-rate basis*[1]

Amount of tax per acre on present basis.			Amount of tax per acre, timber to be taxed when cut at a flat rate per M; land to be taxed annually, interest compounded at 5 per cent.							
Tax on timber and land 50 cents per annum.			On standing timber, yield 50 M. b. f.				On land at 10 cents per annum.		Total tax on timber and land per acre.	
			Rate per M.		Tax per acre.					
Period, years. (1)	Ave per annum. (2)	For period. (3)	Per annum. (4)	For period. (5)	Per annum. (6)	For period. (7)	Per annum. (8)	For period. (9)	Av per annum. (10)	For period. (11)
1-5	$0.55	$2.75	$0.01	$0.05	$0.50	$2.50	$0.11	$0.55	$0.61	$3.05
1-10	.63	6.29	.01	.10	.50	5.00	.13	1.26	.63	6.26
1-15	.72	10.79	.01¼	.19	.62	9.50	.14	2.16	.76	11.66
1-20	.82	16.54	.01¼	.25	.62	12.50	.16	3.31	.78	15.81
1-25	.95	23.86	.01½	.37	.75	18.75	.19	4.77	.94	23.52
1-30	1.10	33.22	.01¾	.52	.87	26.10	.22	6.64	1.09	32.74
1-35	1.29	45.16	.02	.70	1.00	35.00	.26	9.03	1.26	44.03
1-40	1.51	60.40	.02½	1.00	1.25	50.00	.30	12.08	1.55	62.08
1-45	1.77	79.85	.02¾	1.24	1.37	61.65	.35	15.97	1.72	77.62
1-50	2.09	104.67	.03¼	1.62	1.62	81.00	.42	20.93	2.04	101.93

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[1] Special acknowledgment is made to E. G. Ames, of Seattle, for valuable assistance in preparing this table.

The foregoing tables are presented merely to explain the general plan, which, in practical operation, would need to be modified from time to time to meet new conditions as they might arise. They are worked out for Douglas fir in western Washington, because more reliable data on which to base such tables are available for this species in this part of the State than for the State at large. Similar tables would be constructed for other species.

In Table 1 columns 2 and 3 show the amount of tax per acre the State would collect for different periods of years under the plan now in operation, the land and timber to be assessed annually at 50 cents per acre. Columns 10 and 11 show the amount of taxes which would be paid under a plan which would place an annual tax on the land of 10 cents per acre and a percentage tax on the stumpage value of the timber when it is cut. It is assumed that the average stumpage value of Douglas fir cut in the next five years would be $2 per M; $3 per M for the second five-year period; $4 for the third, etc. Thus in 40 years stumpage values for red fir would rise to $10 per M. The same price is assumed for the next periods on the assumption that stumpage values will not rise much beyond this figure. The values as stated are assumed, but in actual practice stumpage values could be estimated for short periods and thus made to conform very nearly to real values.

The rate per cent on the stumpage value as given in column 5 is determined in the following manner: A stand of 50,000 board feet per acre is assumed. It is shown later in this report that the average tax per acre in western Washington at present is about 50 cents. Since, under the proposed scheme, 10 cents per acre annually is assessed against the land, the balance of 40 cents per acre would be levied on the timber, assuming that timber property would pay the same amount of tax under the proposed system as under the present one. Dividing the amount to which an annual tax would accumulate at 5 per cent compound interest in any given period by the value of the timber for the same period gives the assessment rate per thousand for that period. For example, an annual tax of 40 cents at 5 per cent interest, compounded, amounts in five years to $2.21. The yield for 50,000 feet multiplied by $2, the stumpage value assumed for the first five-year period, gives $100 as the value of the timber per acre. The accumulated tax of $2.21 divided by $100 gives 2.2 per cent as the rate per cent at which stumpage is to be assessed for the first five-year period. Thus the tax per acre for the period would be $2.20, as shown in column 7, or 44 cents per acre per annum, as given in column 6. Manifestly, the man who cuts in the first part of the period—say in the first or second year—should not pay the same amount of tax as the man who cuts in the fifth year. The scheme, therefore, contemplates that the timber which is cut early in the period shall be assessed at a per annum rate, as given in column 6.

. By comparing columns 10 and 11 with columns 2 and 3 it will be seen that, under the conditions assumed, the scheme proposed would yield practically the same revenue as the one now in vogue.

Table 2 differs from Table 1 mainly in the method of assessing the yield tax on the timber. Like Table 1, it provides for an annual tax of 10 cents on the land, but instead of placing the yield tax on a percentage basis, it taxes the timber at a flat rate, varying, according to the period in which the timber is cut, from 1 cent to 3¼ cents per thousand per annum. For example, for the first five years the tax would be 1 cent per thousand feet per annum—that is, if the timber were cut in five years, the tax upon it would be 5 cents per thousand. The rate gradually increases until for a 50-year period it is 3¼ cents per annum.

The plan proposed in Table 2 yields approximately the same revenue as would the present scheme, assuming that the present rate of taxation should remain unchanged. This is shown by comparing columns 2 and 3 with columns 10 and 11. Neither table, therefore, proposes any reduction of the present tax on timber land. On the contrary, a rather high rate of compound interest is allowed the State for deferred payment of taxes.

Both tables are constructed on a sliding scale, starting with the present rate of taxation as a basis, so that timber owners would suffer no disadvantages in changing to the new system by reason of having paid taxes prior to the change under the old system.

The chief advantage of Table 1 is that since it assesses the timber on a percentage basis it allows for differences in value, due to inaccessibility, quality, or other causes, while Table 2 taxes all timber at a flat rate, regardless of value. Table 2, however, has the merit of simplicity of operation, since the value of the stumpage does not need to be appraised, as is required by Table 1. A scheme which makes allowance for differences in the value of timber on account of location or other cause distributes the tax burden more fairly than would be the case otherwise.

The criticism has been made that a scheme of taxation which would tax forest land annually and defer the tax on the timber crop till it is cut would discriminate against the farmer. This is not the case. On the contrary, the present system of taxation discriminates against the forest crop. For example, theoretically, farm crops are taxed. Practically they pay very little tax, because assessments are made at a time when there are no farm crops in the ground, and by the time the next assessment is made they have been grown, harvested, and very probably marketed. Hence, as a rule, the land only is assessed.

The plan outlined in the above table calls for an annual tax on the land based on a fair value, and not only does not ask that the timber crop be exempted from taxation, but provides for the equivalent of an annual tax equal to the present tax and allows the State a rate of interest on deferred payments above what the State would have to pay for borrowed money. As stated, farm land is taxed annually; theoretically, the crop is taxed once, and that when harvested. The proposed system asks only that for purposes of taxation virgin forest property be placed on the same basis as farm property, so that the timber crop would be taxed but once, and that when harvested—with this difference, that, while farm crops usually escape taxation, this plan provides that the tax on the timber crop shall actually be paid.

This report has pointed out that the present tax system undoubtedly tends to premature cutting. The point has been made that it might be to the highest interests of the State to hasten clearing on so much of the timber area as is suited to agriculture, since such land, if under cultivation, would produce a larger income than it will in timber. In answer, it is only necessary to call attention to the fact that there are today several hundred thousand acres of logged-off agricultural land lying idle. It will be many years before this land is all taken up and settled. Moreover, timber land fit for agricultural purposes is being cleared far more rapidly now than it is being brought under cultivation. It is apparent that it is folly to cut the forest faster than market conditions warrant and agricultural needs demand.

Difficulties in the Way of Making the Change

The change from the present methods of taxing forests to a dual system, whereby the land is taxed annually, and the timber on yield when cut has distinct advantages—both to the timber holder and to the State at large—though some difficulties are in the way of making it.

The advantage to the individual is that the bulk of the tax falls due when he realizes upon the crop. If, perchance, the growing crop is destroyed by fire before it matures, the State justly shares the loss to the amount of the tax on the crop. Since the State in this way would assume a part of the risk, it would be more apt to provide adequate fire protection.

The State at large would benefit by the change, because the new system, by encouraging the holding till market conditions were right, would promote conservative lumbering, thus husbanding the present timber supply. The chief difficulties in the way of making the change are that the tax revenue from the forests would be considerably less for the first few years, and it would accrue disproportionately to the different timbered counties, since the cut is relatively unequal in them. Attention has been called to the fact that the timber lands paid probably upward of $2,250,000 in taxes in 1910. Under the proposed plan the 6,022,947 acres of timber land in private ownership, if assessed at 10 cents per acre, would have paid nearly $602,295. In 1909 the cut was 3,862,916,000 feet. Assuming a four-billion-feet cut for 1910 (actual figures not available), and assessing the cut at 1 cent per thousand, as is proposed in Yield Tax Table 2 the first year under the new system, the tax revenue from the timber cut would have been $40,000. Adding the tax revenue of $602,295 as the tax on the land to the revenue on the cut gives about $642,000 as the total tax revenue from the virgin timber holdings under the new scheme as against $2,250,000 or better under the present plan. The difference must necessarily have been absorbed by other classes of property. To put the matter in another way, timber land, instead of paying something over 8 per cent of the taxes, as it did in 1910, would have paid a little more than 2 per cent under the new plan. Taxes on other classes of property for the State as a whole would be increased about 6 per cent the first year. This extra burden would be gradually decreased from year to year, and the revenue from the timber holdings would correspondingly increase until it would equal the present revenue, and from that on would exceed it. In the end other classes of property would not be compelled to bear any extra burden on account of the change, and it is believed that the proposed system would assist materially in perpetuating the lumber industry.

As far as the State at large is concerned, the difficulties in the way of making the change do not seem insurmountable. However, in the counties where the timber lands pay such a large proportion of the taxes, in some cases, as this report has pointed out, up to 30 or 40, and even 50 per cent, the obstacles to a change are more formidable, if not prohibitive. Here the interests of a public nature are so dependent upon tax from timber lands that a complete immediate change seems unwise, even if it were possible.

Again, it is believed that if the State should enact legislation which would assess the land annually and the timber when cut, it should exact from the timber-land owners benefiting by the law that they harvest the present crop in such a way as to insure a second crop.[1] "The Supreme

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[1] Taxation of Forest Lands, by A. C. Shaw, Proceedings of the International Conference on State and Local Taxation, held at Toronto, Canada, October 6-9, 1908.

Courts of the United States and of the States of Maine and New Jersey have recently announced decisions which indicate a belief that the State has a right to regulate cutting upon private lands or protect forests and stream-flow on such private lands because of the public service of the forest and the streams."

Recommendation for Remedial Legislation

As applied to the present stand of merchantable timber, therefore, it is recommended:

That a change be made in the method of taxation which will lay an annual tax of 10 cents per acre and a tax on the timber when cut; provided, that whether such timber land shall be taxed according to the system herein proposed shall rest in every case at the option of the owner; provided, further, that any timber-land owner taking advantage of the new system shall enter into an agreement with the State to so harvest the present crop of timber as to insure the establishment of a new crop, either natural or artificial.

The foregoing plan would insure an introduction of the new system on a scale so gradual as to produce no serious reduction in the amount of the revenue now derived from the timber lands. Very little, if any, such lands as are of agricultural value would be affected by the new system, since the new system carries with it the obligation on the part of the owner who takes advantage of it to reforest his lands as fast as he removes the present crop. It is not expected that owners of lands having genuine agricultural worth will care to hold them for a second crop of timber. Again, only such owners as those who, because their lands are at present inaccessible or for some other reason, expect to hold them for a number of years would take advantage of the new law. The practical result would be that in the main only such timber holdings as are non-agricultural in character and non-accessible would come under the operation of the new system, and these are the lands most in need of such remedial legislation.

It is understood that a constitutional amendment would be necessary before the above plan could become effective.

REFORESTATION

The Need

This report has called attention to the fact that of the more than 8½ million acres of land, exclusive of town and city lots, in private ownership in western Washington, probably not over one-half has agricultural possibilities. This means that upward of 4,000,000 acres of these lands will never be fit for anything else than the growing of timber, and should be devoted permanently to this use. Several hundred thousand acres, possibly one-fourth of these lands, have already been logged off. An unknown proportion has reforested through natural agencies. The rest lies idle, and represents so much non-productive capital. This non-producing area will be constantly increased as additional lands are logged off, until eventually a large proportion, perhaps the greater part, of the probable 4,000,000 acres of non-agricultural land will be in a deteriorating, non-productive condition, unless taken over and reforested by the State, or unless conditions are created whereby private initiative can afford to do it. As idle lands they will in time become an incumbrance upon the State; if reforested they will produce timber in great abundance.

As an Investment for the State

Three tables are given below calculating the probable cost of growing Douglas fir in western Washington and estimating the returns. Tables are given for western Washington only, since satisfactory data on which to base tables for growing yellow pine in eastern Washington are not available.

The yields are those given in Forest Service Circular 175.[1] They are for even-aged stands of Douglas fir, growing on soils of first quality, though non-agricultural.

The stumpage prices are based upon prices which, according to Kellogg and Ziegler,[2] are obtained for eastern white pine of similar ages in New England. It does not seem improbable that Douglas fir started now will be as valuable by the time it comes into merchantable size as white pine is at present. The increase from decade to decade is based not so much on the supposition that stumpage prices will continue to be rising at that time as that the older timber will be of better size and quality. The apparent discrepancy in the stumpage value of $5 in 40 years, as given in these tables, and that of $9 40 years hence, as given in the yield-tax schedule, is explained by the fact that values in the yield-tax schedule are for very large old timber, while those given here are for young growth.

In these tables the value of the land is reckoned at $3 per acre. It is assumed that only absolute forest land—that is, land suited only to the growing of timber—will be devoted permanently to this use, and this is believed to be a fair valuation for such land.

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[1] The Growth and Management of Douglas Fir in the Pacific Northwest, by T. T. Munger.

[2] "The Cost of Growing Timber."

In the matter of restocking, three cases are assumed. In Table 3 no allowance is made for this item, as a certain portion of the land can be expected to restock naturally, and without expense to the owner, following logging operations. The large areas of fine young growth to be noted on old logging works in Washington, more especially west of the Cascades, have all reproduced in this way. In Table 4 an expense of $4 per acre is allowed for restocking the ground. In this case it is contemplated that the land will be restocked from seed trees left here and there or by planting the seed. It is believed that restocking can be successfully accomplished by these methods for this amount. In Table 5 it is assumed that the land will have to be restocked by planting young trees, as in many cases a crop can be established in this way where the use of seed trees or direct sowing would fail. It is estimated that $7 per acre will cover the cost of the plant material and labor for planting. This is the actual cost of restocking by this method in New York, where it has been used extensively.

Taxes are figured on two bases, designated as "present plan," which taxes both the timber and the land annually, and "field plan," which defers the taxes till the timber is cut, the accumulated tax on both the land and timber then to be assessed against the timber. In 1910 the average assessed value of timber lands west of the Cascades, exclusive of those in Clarke and San Juan counties, where the timber lands were not segregated, was $16.73 per acre. This valuation, at a 30-mill-tax rate, gives a tax of slightly over 50 cents per acre. The average stand of timber in western Washington, based upon the estimate made in this report, is 40,184 feet. If it is assumed that this average will hold for Douglas fir stands, and that fir is worth $2 per thousand, the average acre of fir has a true value of about $80. However, it is probable that fir stands will average in volume somewhat above the average for all species. It is also possible that the value of $2 per thousand is a little high. The average of 185 replies on the value of Douglas fir west of the Cascades is $1.86 per thousand. If this reduced value is applied to the probable real yields of fir, the value of $80 per acre would still be approximately correct. If 10 cents per acre is assessed as a tax against the land, then the balance of 40 cents per acre would be assessed as a tax against the timber, which is one-half per cent of the assumed true value of the timber. Some of the logged-off land in western Washington is taxed at less than 10 cents per acre, but much of it is taxed at more, and 10 cents per acre is probably none too high for the average. The value of the young timber usually is not taken into account till after it comes to be of merchantable size. Douglas fir begins to have value for poles and ties when it is about 40 years old. Therefore, in the "present plan" the land is assessed at 10 cents per acre annually and the timber annually at one-half per cent of its estimated true value after 40 years from the time the forest is established, the timber to be recruised every 10 years.

In the "yield plan" a tax of 12½ per cent, or one-eighth of the stumpage value, is assessed against the timber when it is harvested, in lieu of the annual tax on the land and timber. A 12½ per cent tax on the gross yield is believed to be fair to the State, and at the same time does not impose a tax burden, which in itself would make forestry unattractive to private capital. A comparison of the two plans shows that under the conditions assumed there is no great discrepancy in the revenues from them up to 50 years. After that the "present plan" gives a revenue considerably greater, but this only shows the fault of the system, in that it greatly overtaxes the crop as it approaches maturity, while the yield-tax system imposes a tax which is uniformly proportional to the value of the timber at all periods.

Table 5 is designed to show the possibilities for the State in growing Douglas fir; hence the factor of taxes is not taken into account, since the State does not pay taxes on its property.

In Tables 3 and 4 interest is compounded annually at 5 per cent. In Table 5 a compound-interest rate of 4 per cent is used, as the State can borrow money at this rate. Even a 5 per cent rate will hardly attract private capital for the present, unless there is, as Tables 3 and 4 indicate, a reasonable assurance of a margin of profit above this rate.

TABLE 3.—*Estimated returns from growing Douglas fir in western Washington*

Age, years.	Yield per acre, feet b. m.	Estimated value per M.	Estimated value per acre.	Cost per acre.							Estimated net gain per acre if taxes are levied according to	
				Land.	Stocking.	Protection and administration.	Taxes.		Total if taxes are levied according to			
							Present plan.	Yield plan.	Present plan.	Yield plan.	Present plan.	Yield plan.
40	12,400	$5.00	$62.00	$18.12	$0.00	$3.62	$12.08	$7.75	$33.82	$29.49	$28.14	$32.51
50	28,000	6.00	168.00	31.40	0.00	6.28	24.84	21.00	62.52	58.68	105.48	109.32
60	41,000	7.00	287.00	53.04	0.00	10.61	49.85	35.88	113.50	99.53	173.50	187.47
70	51,700	8.00	403.60	88.28	0.00	17.66	91.38	50.45	197.32	156.39	206.28	247.21
80	61,100	9.00	549.90	145.68	0.00	29.14	155.65	68.74	330.47	243.56	219.43	306.34
90	70,300	10.00	703.00	239.19	0.00	47.84	252.57	87.88	539.60	374.91	163.40	328.09
100	79,800	10.00	798.00	391.50	0.00	78.30	398.32	99.75	868.12	569.55	[1]—70.12	228.45

TABLE 4

40	12,400	5.00	62.00	18.12	28.16	3.62	12.08	7.75	61.98	57.65	0.02	4.35
50	28,000	6.00	168.00	31.40	46.87	6.28	24.84	21.00	109.39	105.55	58.61	62.45
60	41,000	7.00	287.00	53.04	74.72	10.61	49.85	35.88	188.22	174.25	98.78	112.75
70	51,700	8.00	403.60	88.28	121.71	17.66	91.38	50.45	319.03	278.10	84.57	125.50
80	61,100	9.00	549.90	145.68	198.25	29.14	155.65	68.74	528.72	441.81	21.18	108.09
90	70,300	10.00	703.00	239.19	322.92	47.84	252.57	87.88	862.52	697.83	[1]—159.52	5.17
100	79,800	10.00	798.00	391.50	526.00	78.30	398.32	99.75	1,394.12	1,095.55	[1]—596.32	[1]—297.55

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[1] Loss.

TABLE 5

Age, years.	Yield per acre, feet b. m.	Estimated value per M.	Estimated value per Acre.	Cost per acre.				Estimated net gain per acre.
				Land.	Stocking.	Protection and administration.	Total.	
40	12,400	$5.00	$62.00	$11.40	$33.61	$2.85	$47.86	$14.14
50	28,000	6.00	168.00	18.32	49.75	4.58	72.65	95.35
60	41,000	7.00	287.00	28.56	73.64	7.14	109.34	177.66
70	51,700	8.00	403.60	43.71	108.99	10.93	163.63	239.97
80	61,100	9.00	549.90	66.15	161.35	15.79	243.29	306.61
90	70,300	10.00	703.00	99.36	238.84	24.84	363.04	339.96
100	79,800	10.00	798.00	148.51	353.53	37.13	539.17	258.83

As an Investment for the State

These tables indicate a handsome profit for the State in the business of reforestation, since it pays no taxes and could capitalize the work at a low rate of interest. Table 5 contemplates an initial outlay of $10 for the purchase of the land and restocking, yet the margin of profit is large enough to justify the State in undertaking reforestation under conditions much less favorable than those assumed. It will be remembered that the yields given are for forest land of first quality. There is a considerable acreage less promising that should be reforested, and in some cases it will be necessary to use species less profitable than Douglas fir. The State could take these lands over and reclaim them permanently for the production of timber, with reasonable assurance of paying returns.

The State now owns a large area of forest land. Its forest holding west of the Cascades alone originally approximated 800,000 acres. The timber has been sold from a considerable part of the State's original forest holdings, though only a small portion of the land itself has been sold. All the unsold lands, whether in timber or cut over, should be examined to determine which have agricultural possibilities and which are chiefly valuable for forestry. The latter should then be constituted a State forest, to be devoted permanently to the production of timber. This much land would have been secured without cost; hence the item of $3 per acre in the above tables would be eliminated in reckoning the cost of growing timber by the State. Again, a certain part of the cut-over land has reseeded naturally; hence the cost of restocking would be eliminated. But a large portion of these cut-over lands, owing to recurring fires, are not reforested. These should be reclaimed by planting. As the remaining timber is sold, it should be done under such contract as will insure successive crops. This State forest should be added to from time to time through the purchase of cut-over land suitable only for reforestation.

As an Investment for the Individual

Attention has been called to the large areas of fine young stands of timber that have come in through natural reseeding following logging operations. As additional lands are cleared, a certain percentage can be expected to seed up in the same way. With some care in logging, this self-seeded area can be greatly increased with very little initial outlay. Just how far private capital can afford to go in the matter of reforestation is problematical. Somewhere between the cost of holding land for a second crop, that seeds up naturally with little or no expense, and the maximum cost of holding it where the crop must be established by artificial means, is a dividing line beyond which the individual cannot go. This point is shown in the foregoing tables. Table 1 indicates that Douglas fir land of good quality, on which a new crop has been secured without expense to the owner, is a profitable investment, if the crop escapes fire and is cut under 90 years. Under a fair yield-tax system the 100-year-old crop produces a satisfactory net gain. It should be remembered that under the conditions assumed in these tables the investor realizes 5 per cent compound interest on his capital, if the returns from the crop just equal the cost. Any returns above cost are gains above this rate.

If to the value of the land $4 for stocking is added, as in Table 4, making the initial expense $7 per acre, there is shown a safe margin of profit above 5 per cent interest if the crop is cut at 80 or under. It would not seem that private capital at this time would be justified in engaging in reforestation where an initial outlay of much above $7 per acre is necessary.

However, since forest reproduction is largely a matter of controlling the fire hazard, and now that this problem has fair promise of solution in this State, a large amount of private forestry seems justifiable. If private initiative can have additional encouragement in the matter of reforestation through the inauguration of a rational tax system as applied to cut-over lands, it can go forward still another step to its own advantage.

Attitude of Lumbermen on the Subject

In order to test the sentiment of owners of cut-over lands on the matter of reforestation, three questions bearing on this subject were included in the outline used in this study. These questions and the answers follow:

7.—Are you selling your cut-over land to settlers or others for farming land?

Answer.	Number.
Yes	171
No	216
Doubtful	9
Expect to	42
No answer	85
Total	523

Owing to the expense of clearing logged-off lands and the high price at which they are held, there is not a brisk demand for them, even where they have agricultural value. While this table shows that there is some sale for them, yet the great body of logged-off lands is still in the hands of the lumbermen. There is little or no exchange of cut-over lands for purely forest purposes.

8.—Are you holding your cut-over land for a second cut?

Answer.	Number.
Yes	64
No	306
Doubtful	44
Have none	50
No answer	59
Total	523

Deducting the 50 replies which do not represent cut-over land from the total number of replies received leaves 473. Of this number 64, or 13.5 per cent, say they are holding their cut-over lands for a second cut. This showing is significant, considering the fact that these lands are assessed annually, and that till within recent years they were absolutely without fire protection, and indicates that with proper encouragement in the way of fire protection and faverable tax laws private capital will engage in the business of reforestation on a considerable scale.

9.—Would exemption from taxation on young growth until it is cut, and a tax then to be paid upon the amount of timber cut, influence you to hold your cut-over lands for a second cut?

Answer.	Number.
Yes	216
No	141
Doubtful	75
No answer	87
Believe State should undertake reforestation	36
Total	555

In the preceding table it was noted that 13.5 per cent report that they are holding their cut-over lands for a second cut. In this table it is interesting to note that 216 replies, or 39 per cent of the total, state that they would hold for a second cut if the tax reform, as indicated in the question, were brought about, showing clearly that the present tax system discourages private reforestation. The 36 replies expressing belief that reforestation is the function of the State, emphasize a sentiment which prevails quite generally—that the State should go into the business of growing timber on a comprehensive scale.

From the tables estimating the returns from growing Douglas fir, it will be seen that taxes on the present basis of assessing timber land are an excessive proportion of the cost of growing timber. Under the conditions assumed in Table 7, where no outlay is required for restocking, the taxes constitute from 36 per cent to 47 per cent of the total cost of producing the crop, varying according to the age at which the timber is cut. The percentage of tax to the total cost is highest when the crop is 80 to 90 years old, the most desirable age at which to harvest. With the conditions assumed in Table 8, when an outlay of $4 per acre is made for restocking, if the timber were harvested when 80 to 90 years old, the amount of the tax would be 29 per cent of the total cost of producing the crop. Taxation at these rates is confiscation. It is the more unjust in view of the fact that, however effectively the growing crop may be guarded against fire, the owner always takes a chance of having it burn before it matures. This is a risk the State should share, as it would do if the tax were not paid till the timber is cut, or, to put it another way, the State cannot in justice exact a tax on a crop which, through no fault of the owner, may never be harvested.

Attention is called to the fact that a large proportion of the taxes under the present system occurs as a tax on the land aside from the timber. If the land is assessed annually at even a so-called nominal figure, the tax mounts up into high figures in long-time periods. A tax of 10 cents per acre, if paid annually, and 5 per cent compound interest is allowed on the payments, amounts in 80 years to $97.12, and in 100 years to $261.

Recommendations for Remedial Legislation

This report endorses the principle of a yield tax as applied to virgin timber. But it is recognized that a certain fixed amount of revenue must be raised in the State annually. If a change in the method of taxation were brought about whereby taxes on virgin timber were to be deferred till the timber is cut, the most of the tax revenue now derived from this source would have to be apportioned temporarily upon other classes of property. Hence to apply the yield tax to all virgin timber land at one time would require changes in the present method of raising revenue that would make its adoption impracticable, if not unwise. Therefore, as applied to virgin timber, a modification of the yield-tax system has been recommended which it is believed will give relief where most needed, and at the same time will not work a hardship on other classes of property holders.

In the case of cut-over land, however, the yield tax, if adopted, would, from the nature of the case, take effect so gradually as to create no disturbance whatever in the present method of raising revenue, and could not affect disadvantageously other classes of property. In the first place, the total acreage now cleared which would ultimately be affected by the change pays a tax revenue which is a mere bagatelle as compared with the total raised, and this acreage would be benefited by the change only at the option of the owner, and as it should prove to have been reforested.

It is, therefore, recommended that, as an encouragement to private capital to hold cut-over land for successive crops of timber, the State should exempt both the land and the growing crop from taxation, a yield tax of a certain percentage of the stumpage value to be levied against the timber when it is cut.

As in the case of virgin timber, a constitutional amendment would be required before a reform of this nature could be possible.

REVIEWS

Management of Pine and Spruce in Sweden[1]

Sweden, because of her large timber resources, was one of the last European countries to place her forests under conservative management. Extensive tracts of virgin timber are in private hands and are being exploited on a commercial scale. Nevertheless, intensive forestry has been practiced in certain localities for half a century or more. With respect to the progress made, Sweden may be regarded as occupying an intermediate stage between Austria, Germany, and France on one hand and the United States on the other.

The article reviewed in the following pages appears in a volume published by The Society for the Conservation of Forests (Föreningen för Skogsvård). While the article was written in 1907, it may doubtless be regarded as fairly representative of the practice in Sweden at the present time.

Through improved transportation facilities and the rise of new industries it has become possible in recent years to secure fairly good utilization of forest products. The smaller materials which formerly could be disposed of only in the most favorably situated localities can now be handled with profit. These conditions have made possible a more intensive management than could be practiced formerly.

Sweden's forests are of a diversified character, varying from the dense spruce or beech to the open pine and birch stands. Scots pine and spruce, which often grow in mixture, are the most important species commercially.

CARE OF YOUNG STANDS

Cleanings

The first thinnings are made when the seedlings are not less than five years old. They are not considered safe from the dangers of drouth, frost, etc., until they have reached this age. When the plants are from one-half to one meter high competition becomes strong and further thinning becomes necessary. In a mixture of pine and spruce, the pines, owing to their rapid height growth, threaten to suppress the spruce, and in extreme cases the former are removed.

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[1] **Skogsvårdsföreningens Folkskrifter. 1-12, No. 12, "Skogens Vård Ock Afverkning," by F. Aminoff.**

The birch often makes its appearance in young stands, and must be held in check, because, through its rapid growth, it often suppresses the conifers. On poor sites a limited number of birch is considered desirable, since they fill openings and protect the soil from drouth. Their abundant foliage protects the young conifers from snow pressure and increases the fertility of the soil. On such sites the birch should be allowed to remain until the conifers are at least 30 years old.

Another broadleaf tree which is considered an objectionable weed on cuttings is the aspen. This tree often springs up in such dense stands as to keep out all other forest trees.

Finally, all crooked and otherwise misshapen seedlings are removed. It is especially important to eliminate forked seedlings, since, if left until later, their removal will leave too large an opening in the stand.

All the cleanings are preferably carried out in rainy weather, when the soil is loose and facilitates pulling up plants by the roots. No direct net returns are expected from the cleanings, which involve trees at most only 15 years old.

Thinnings

Thinnings take place when the stand begins to prune itself. In southern Sweden this stage occurs at from 25 to 30 years, while in upper Norrland it does not occur until an age of 50 or 60 years is reached. It is considered of great importance to keep the crown cover closed from the beginning in order to promote natural pruning. The removal involves primarily suppressed trees, and among dominant trees those which show injuries or bad form, such as "wolf trees." Under no circumstances, however, must dominant trees be removed to such an extent as to form openings in the crown cover.

The time is now ripe to encourage diameter growth. This is accomplished by heavier thinnings, thus favoring the development of the crowns. Greater inroads are made upon the dominant tree class, removing first "wolf trees" and individuals with poor crowns.

On poor sites it is important to thin pine in time. There are many examples of pine stands on burned-over or otherwise impoverished soils, which, owing to their great density, have practically stopped growth, and cannot recover even after thinnings are made. Spruce, on the other hand, endures suppression for long periods. While heavy thinnings must be avoided in spruce, early and fairly strong thinnings are often advantageous in order to encourage wind firmness. This applies especially to stands growing on good sites. If the thinning is delayed too long the trees become subject to drouth and windfall.

Where pine and spruce grow in mixture, thinnings must be made with special reference to the soil. On rich soil, where one seeks to retain the mixture, the pine must be cut out in places in order to preserve the spruce. On poor sites, on the other hand, where the spruce occurs in great numbers, it should be removed as rapidly as possible, because through its strong food consumption it tends to starve out the pine.

Where birch occurs in mixture with conifers it should generally be weeded out, since it injures the latter by whipping, and even by shading. In southern Sweden it is not uncommon to find even-aged forests of spruce and birch in which the tolerant spruce has been checked in its growth by the birch. As already pointed out, a moderate amount of birch is desirable on poor sites, especially in northern localities.

As a rule, the thinning should be lighter on weak than on strong soils. Heavy thinnings on weak soils may result in an open and uneven stand. The consequence is that the soil becomes hard and grows up to weeds. On strong soils the trees have a greater vitality and respond more quickly to increased growing space, so that the openings in the canopy are soon closed.

Light Cuttings

The object of light cuttings is to secure the greatest possible increment from the most vigorous trees. The removal is so heavy that the crowns no longer meet. Usually a space of from one-half to three-fourths meter is left between the extreme tips of the branches of neighboring crowns. Light cutting is especially distinguished from the earlier thinnings in that the former always aims to keep the crown cover fully closed. On account of danger from windfall the pine is the only Swedish conifer in which light cuttings can be made to advantage. In order that trees may avail themselves of the increased light, the crowns must be in good condition. This is seldom the case in a stand which has not previously been thinned. In the absence of sufficient light, the crowns have in early life lost the power of further development. The conditions necessary to secure returns from a light cutting are good soil and good crown development. While light cuttings cannot be said to be generally practical at the present time, they promise to become important in the future.

EXPLOITATION OF THE STAND

The two general forms of cutting are clear cutting in groups (Trakthugging) and the selection method (Blädning). In practice the two methods frequently merge into one another.

Clear Cutting in Groups

One of the first precautions in this method is that the cuttings should not be too large. Large cuttings make natural reproduction difficult by giving too much access to wind and sun, permitting the growth of weeds and exposing the stand to windfall. The openings should not exceed one hectare in area, and they are preferably of a rectangular form, with the long axis perpendicular to the prevailing wind direction.

If natural reproduction is sought, an adequate number of seed trees are left distributed as uniformly over the area as possible. Their function is not only to seed the ground, but also to shade it. For this reason more seed trees are required on poor than on good soil. On sites exposed to wind the trees must also stand closer than in protected situations, since in the former one must always expect more or less loss from windfall. It is evident from the foregoing that the spruce, on account of its shallow root system, does not generally meet the requirements for a seed tree, and therefore only individuals which have grown up in fairly open situations should be left.

Underbrush is cleared away in the cutting, since it will otherwise interfere with reproduction. Well-developed groups of young trees are spared; but single plants are in no case left, however promising they may appear, because as a result of the increased light after cutting they will soon become limby and will eventually occupy too much space. On the poorer sites it is often desirable to leave an occasional birch as a seed tree in order to secure the much-desired mixture with broadleaf trees.

The vital point in this method of cutting lies in the selection of the seed trees. A seed tree must produce an abundance of seed, be wind firm. and possess a desirable form. A strong, well-developed crown is regarded as the most reliable indication that the tree is a good seed producer. Trees with weak, thin crowns, such as they become in close, unthinned stands, are poorly adapted to seed production unless they are liberated in time while the crowns are still capable of development. Middle-aged seed trees are regarded as most desirable. Old trees show a lower germination. It is, however, often necessary to leave old trees for want of young ones. Good form is regarded as important because the form is believed to be influenced not only by climatic conditions, but also by heredity.

The best time for cutting is the year before a seed crop, but since seed years are rather irregular it is necessary to cut also during the intervening period. Condition of the soil plays an important rôle in the success of natural reproduction. In old open stands the ground is often covered with a luxuriant vegetation, and after cutting this increases. In order to check herbaceous growth, limbs and tops are left to shade the ground until a seed year occurs, when this material is removed.

On deep, rich soil the brush is burned broadcast over the cutting area. On sterile, shallow soil fire must be used with caution, since the food elements may be so limited that further reduction by burning will lead to impoverishment. On such soil the brush is burned in piles laid, if possible, on stones. In any event the fire should not be so intense as to injure the soil, the main object of burning being to remove slash and other material which will interfere with reproduction.

In northern regions, where reproduction suffers from heavy snows and frost, more or less slash is left on the ground to protect the young plants. The slash also keeps out grazing animals.

The soil is loosened by plowing or by hand cultivation. This is especially helpful on lichen-covered heaths, where seedlings spring up in abundance, but later pine away. Lack of cultivation is often the sole cause for the absence of reproduction. Where the plow is used it should precede the cutting, since then there is no interference from logs and tops.

Reproduction is not always secured after the first seed year. One should therefore not be too hasty in removing the seed trees. When the reproduction reaches the height of at least one-half meter, it is time for the removal of seed trees, which should take place when the snow is deep. Where the seed trees are close together they should not all be removed in one cutting, since sudden exposure may injure the young growth. In such cases removal should take place in two or three cuttings at intervals of about three years.

Clear cutting in groups is adapted only to practically even-aged stands, in which the bulk of the trees are ready for the axe at the same time. In no case should there be a range of more than 30 or 40 years in the age classes. From an economic standpoint it is also necessary that there be a market for material of small dimensions, since even in stands of even age there is considerable variation in the diameters.

The Selection Method

The selection method is well adapted to uneven-aged forests where there is no market for small material. It has greater possibilities for intensive management than the preceding method; but, on the other hand, greater technical ability is required to carry it out.

In the selection method overmature, injured, and diseased trees are the first to be removed. Next come the spreading "wolf trees." Often the removal of a single tree of this character leaves space for several smaller ones which have been shaded by it. Advantage is taken of natural openings, in which groups of reproduction occur. Trees are removed in the edges, leaving sufficient space to allow development at least 10 or 15 years in the future. The cutting is always strongest on the side of the opening which is best protected from the wind, especially in spruce, which is subject to windfall. If necessary, new openings are made to encourage further reproduction. The size of the openings depends upon the species and soil. In spruce the diameter is equal to the height of the tree, while in pine it is at least one and a half times as great as the height of the tree. On rich soil the openings are smaller than on poor soil.

It is important not to place the openings too close together. This precaution is especially necessary in dense stands, which are subject to windfall. In such stands the distance between the openings should be at least 100 to 150 meters. Thorough cultivation of the cleared ground is important, especially in spruce forests. Tops are often laid so as to form a barrier around the opening to keep out grazing animals.

The advantages of the selection method over clear cutting are better utilization of soil and crown space, less windfall, better seed production, and conservation of soil fertility. The selection method is particularly adapted to spruce. The disadvantages of the method are the cost of cultivating small openings and the fact that the much-desired brush burning is often impossible.

Application of the Methods

In southern Sweden and in the most favorable localities in Norrland, where market conditions permit the utilization of small materials, even-aged pine stands can be clear cut in groups to good advantage. Forests where clear cutting has for many years been practiced in connection with the charcoal industry furnish a striking example of the results of this method on good soil. More promising young forests than those which have sprung up on these areas are scarcely to be found. The only criticism which can be made is that they have given rise to excessively large, continuous even-aged stands of the same species.

In upper Norrland, where the pine is more shade enduring and where seed years are rather irregular, it is foolhardy to clear cut large areas. The selection method is here more suitable. This also applies to the poor mountain soils in southern Sweden and to sites exposed to the wind.

In the southwestern sections of the country there are places where the pine on account of too rich soil seldom reaches its best development. The pine here is partly the result of planting on old heaths. Here the selection method is a suitable form of cutting. By making small openings the introduction of broadleaf trees, such as beech and oak, is encouraged, thus gradually transforming the pine forests into more valuable broadleaf forests.

In all selection cuttings in pine it is important to make the openings sufficiently large. The light in small openings is insufficient for pine, but satisfies the requirements of spruce. If the soil is sufficiently productive so that spruce will develop normally, its presence is not objectionable; but if the soil is unfertile, as is often the case, invasion by spruce is disastrous. The consequence is then a mixture of pine and spruce on soil where pine alone would have done admirably, but where in competition with the poorly developed but nevertheless more food-consuming spruce it gradually succumbs. Such forests occupy extensive areas, and they are in a large measure a memory of the old "timber-selection" days, when only the best timber trees were cut without thought of reproduction. In handling such stands clear cutting in groups, leaving seed trees of pine, is recommended. The spruce should be cut mercilessly and the ground well cultivated. If pine occurs in such small numbers that large openings would result after removing the spruce, occasional young spruce can be left as a protection to the soil until the pine is re-established. Sometimes the succession of spruce becomes so complete that the pine is entirely driven out. The only remedy is then clear cutting on small areas, burning off the ground and sowing with pine seed.

Mixed forests of pine and spruce on good soil commonly occur in southern Sweden and occasionally in Norrland. This mixture constitutes a plant society which should be perpetuated. The advantages are numerous. The pine protects the spruce against wind damage, while the spruce conserves soil fertility. Moreover, a better utilization of the soil is secured, since the pine draws its nourishment from the deeper soil strata, while the spruce draws on the upper layers. If, however, such a stand is left to itself the final result will be that the spruce, since it reproduces better in shade and also produces more seed than the pine, gradually gains the upper hand and crowds out the latter. In order to preserve an equal mixture of the two species clear cutting on small areas, leaving seed trees of pine, is recommended.

Pure spruce stands present the greatest difficulties. This is especially true on productive soils where even-aged spruce stands have grown up without thinnings. In such stands reproduction may be secured by light selection cuttings, in which the openings must not be more than 20 or 30 meters wide. The remaining trees should stand close enough so that the tips of the branches meet. This affords sufficient light for spruce reproduction. The size of the opening is gradually increased until eventually the neighboring openings coalesce. In even-aged spruce forests on poor soil, where the stands are comparatively open and consequently less sensitive to wind, or where the spruce has been hardened by thinnings, the selection method previously described should be used.

G. A. PEARSON.

FLAGSTAFF, ARIZONA,
JUNE, 1914.

ECOLOGICAL INVESTIGATIONS UPON THE TRACHEIDS OF CONIFERS[1]

The study of the effects of climatic and edaphic factors upon the external and internal structure of plants is frequently a very complicated one, and one that must progress slowly in most cases owing to the absence of sufficient reliable data. However, much can be accomplished, when suitable systematic observations are available, by the application of statistical methods.

Groom has recently made an ecological study of conifers based largely upon Penhallow's measurements of the dimensions of the tracheids of North American Gymnosperms. From his investigations Groom concludes that "there is considerable evidence that the width of the spring tracheids in evergreen Coniferæ is largely decided by two factors—systematic affinity and available water supply. So far as the latter is concerned, the spring tracheids are generally narrowest in species of xerophilous habitat." This is shown by the fact that in the American species of Pinus, belonging to the section Haploxylon, the nut pines (subsection Para-Cembra) which occur in edaphically and climatically dry situations possess the narrowest tracheids. Similarly, among the diploxylic series the species with narrow spring tracheids occur in comparatively dry regions, whereas the forms with very wide elements occur in the moist subtropical conditions of the southeastern United States. In India the haploxylic xerophilous *Pinus gerardiana* Wall. possesses narrow spring tracheids (average width, 31.5 micra), but the diploxylic hygrophilous *Pinus merkusii* Jungh. & de Vriese., which grows in moist, tropical conditions, possesses wide spring tracheids (56.5 micra). These facts are confirmed by the variation in the width of the spring tracheids of other genera of the Coniferæ and by the variation in the dimensions of the spring vessels or pores of the dicotyledonous genus Quercus.

Although exception might be taken to certain portions of the data upon which Groom bases his conclusions, the trend of the data as a whole appears to justify the conclusion that in hygrophilous habitats the spring tracheids of conifers possess larger lumens. A natural teleological inference might be that the tracheids were of larger size to facilitate the more rapid conduction of water.

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[1] By Percy Groom. A Preliminary Inquiry into the Significance of Tracheid-Caliber in Coniferæ. Bot. Gaz., Vol. 57, No. 4, pp. 287-307.

Groom, P., and Rushton, W. The Structure of the Wood of East Indian Species of *Pinus*. Jour. Linn. Soc. Lon., bot. 41: 457-490. 1913.

IRVING W. BAILEY.

HARVARD UNIVERSITY,
SCHOOL OF FORESTRY.

HANDBOOK OF PHOTOMICROGRAPHY [1]

The value of photomicrography for purposes of illustrating and demonstrating the structure of plants is now appreciated by many botanists and wood technologists. There are, however, a comparatively limited number of individuals who are able to make photomicrographs of really good quality. This is due in part to defective methods of softening, sectioning, and staining material for photographic purposes, but largely to unfamiliarity with the technique of photomicrography.

Hind and Randles have prepared a handbook which should prove extremely useful to the student of photomicrography. The book, which is the outcome of a series of articles originally published in the *Photographic Monthly*, describes the various types of cameras and microscopes, and devotes chapters to the properties and uses of lenses, illuminants, and condensers. Particularly instructive are the special chapters on critical illumination, low and high power photomicrography, and color screens. The value of the book is much increased by numerous text-figures and reproductions of photomicrographs.

The subject has been approached from the aspect of both photographic and microscopic technique, and the authors have on the whole succeeded very well in emphasizing and explaining those features which are most troublesome to the inexperienced worker.

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[1] By Hind, H. Lloyd, and Randles, W. B. E. P. Dutton & Co., New York.

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Proceedings
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VOL. IX OCTOBER 1914 No. 4

FOREST PLANTING IN ARIZONA AND NEW MEXICO

BY G. A. PEARSON

Contributed

The purpose of this article is to bring together the results at present available from the efforts toward solving the reforestation problem on the National Forests in the Southwest. The data here presented are based on general planting operations in the Southwest and intensive experiments at the Fort Valley Experiment Station and the Fort Bayard Nursery.

Prior to the year 1911 all attempts at artificial reforestation on the National Forests in Arizona and New Mexico had, with a few minor exceptions, met with failure. In that year, as a result of the experience gained during the preceding years of failure, the tide turned, and since then planting has been conducted with fairly consistent success. All the successes have been achieved by planting as distinguished from direct seeding. So persistent have been the failures with direct seeding, despite several years of extensive experimentation, that the method has practically been abandoned. While a discussion of the methods employed in direct seeding might be of interest, it would lead to no practical end, and therefore this article will deal only with planting.

In the light of recent knowledge, the main reason for the early failures lies in the use of poor planting stock. Other factors, such as improper handling and poor sites, doubtless contributed in some instances, but poor stock is a factor which seems to have been ever present and made failure inevitable. The majority of the plants used in those days were of such poor root development that, according to present standards, they would scarcely grade as second class. During recent years an effort has been made to remedy this defect.

NURSERY

The beginning of successful planting is in the nursery. The fact that the production of nursery stock is not an end in itself, but merely the means to an end, was too often overlooked in the first attempts at reforestation in this country. Cheapness of production rather than quality of stock was the object aimed at by the nurseryman. Size of top rather than root development was the criterion by which quality of stock was judged. In no region will these standards lead to such disastrous results as in the arid Southwest, where the young tree is taxed to the utmost to establish itself after planting.

The technique of ordinary nursery practice has been highly developed in the larger nurseries of the Forest Service, and therefore this phase of the problem will not be discussed in detail. I wish to deal more with underlying principles, considering the difficulties encountered and how to overcome them. The production of vigorous nursery stock is usually a comparatively simple matter. The problem in the Southwest has been to produce stock which would successfully withstand field planting. Lack of soil moisture, coupled with excessive water loss from the foliage at critical times, is the main cause of death in young planted trees. From May 1 to July 15 the total precipitation in the yellow-pine type is usually about one-half inch. This period is also characterized by strong winds and extremely low atmospheric humidity. The surface layer of soil to a depth of 6 or 8 inches dries out almost completely; but the deeper strata, which are usually of a clayey texture, retain considerable moisture even after several months of drought. It is evident, therefore, that if a young tree is to survive it must have a root long enough to reach the soil strata which contain sufficient moisture to sustain life. The roots must also have adequate absorbing capacity; they must extend over considerable area in the moist soil strata and must be supplied with an abundance of the fine rootlets or "feeders" which are most active in absorbing moisture. It is here that the stock used in the earlier plantings was deficient. The moisture problem is further solved by reducing water loss from the foliage. This is accomplished by inducing the development of a small but sturdy top. Western yellow-pine planting stock in the Southwest should have a well-developed root system not less than 10 inches long and a stem not over 5 inches long. In Douglas fir and Engelmann spruce, which normally develop shallower and more spreading roots and are usually planted on comparatively moist sites, the contrast between root and top need not be so great as in western yellow pine.

The factors more or less within control of the nurseryman, which are most important in determining the development of the plant, are seed, soil, growing space, water, protection, and cultivation.

Seed

That the seed should be of high and known vitality is well recognized, but the influence of the source of the seed has until recently been given little thought in this country. The theory that the character of forest trees, like other plants, is determined to considerable extent by heredity is now generally accepted. It has been shown by a number of European investigators that such characteristics as form, rate of growth, and hardiness, even though resulting from soil and climatic conditions under which the mother tree grows, may be transmitted through the seed. The most noteworthy investigation on this subject is that of Engler,[1] who has carried on exhaustive experiments with Scotch pine from various localities in Switzerland, Germany, Austria, Belgium, Russia, Norway, Sweden, and Scotland. The results of Dr. Engler's work are summarized in the following quotation from a review by Prof. J. W. Toumey:[2]

> "The author concludes from this comprehensive study of the Scotch pine and from previous investigations that stands having poor growth-form are not suitable to collect seeds from for use in forest practice. Poor growth-form comes from adverse soil conditions and from the use of seed from the wrong locality. In both cases the research shows it can be transmitted through the seed. For each locality the indigenous spontaneous pine is the best to collect seed from for use in that locality. Exotic seed, however, may be used when its origin is known. Thus seed from east and west Prussia is acceptable for use on low elevations in Switzerland, not to exceed 1,000 to 1,200 meters above sea-level. South German seed may be used on the lowlands of north Switzerland. The Auvergne pine may be expected to thrive on the dry soils of the Juras.
>
> "When exotic seed is used it should be with full knowledge of its descent and of the locality where collected. This knowledge, however, can only be attained through government supervision. We now know that the failures in the cultivation of pine in the Swiss mountains in recent years have been due to the use of seed from the wrong localities.
>
> "It appears to the reviewer that the results of Dr. Engler's researches on Scotch pine and Norway spruce and similar investigations in recent years by other investigators clearly show the necessity of giving more

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[1] Engler, Arnold: Einfluss der Provenienz des Samens auf die Eigenschaften der forstlichen Holzgewachse. (In Mitteilungen der Schweizerischen Centralanstalt für das forstliche Versuchswesen, Zurich, 1905, Vol. 8: 81-236; 1913, Vol. 10, No. 3: 1-386.)

[2] Proceedings Society of American Foresters, Vol. IX, No. 1.

attention in this country to the descent of the seed that we use in forest practice.

"With the use of such widely distributed species as western yellow pine, Douglas fir, and even white pine, the success attending their culture in any particular locality may be largely determined by the descent of the seed."

The result of 50 years of planting with Scotch pine in Sweden[3] shows that seed grown in France, southern Germany, and other regions of a decidedly milder climate than that of Sweden produces trees of very inferior form and so poorly adapted to Swedish conditions that entire plantations often die out at the age of 30 or 40 years. In reading Swedish articles on forest management one repeatedly finds the statement that trees of good form should be selected for seed production, since form is believed to be influenced by heredity as well as by soil and climate.

Experiments with western yellow pine at the Fort Valley Experiment Station show a marked difference in the germination of seed from different individual trees in the same locality. Young and vigorous trees which have reached the seed-bearing stage produce seed of considerably higher vitality than old, over-mature trees. Mechanical injuries, such as basal burns and lightning scars, appear to stimulate the tree to the production of better seed. Mistletoe and bark beetles appear to lower the vitality of the seed. No constant relation has been found to exist between the character of the mother tree and the resulting seedlings, but this phase of the experiment has not been carried far enough to yield definite results. Studies of this character are complicated by the fact that since tree flowers are generally fertilized by the pollen from a number of neighboring trees, only one of the parents is known.

Studies on the influence of the geographical origin of seed have not been carried sufficiently far in this country to establish final conclusions. Experiments with western yellow-pine seed from different regions at the Fremont and Fort Valley Experiment Stations, however, show a decided difference between the rate of germination and size and hardiness of the seedlings. Similar experiments with Douglas fir are being carried on at other experiment stations. These investigations should ultimately determine for each locality from what regions seed may be obtained. For the present the safest practice is to use only local seed, collected, as far as possible, from middle-aged, sound, well-formed trees.

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[3] Edvard Wibeck: "Tall ock Gran af Sydlig Härkomst i Sverige." Meddelanden fron Statens Skogsförsöksanstalt, Stockholm, Häftet 9, 1912, pp. 75-134. Reviewed in Proceedings of Society of American Foresters, Vol. IX, No. 1, pp. 113-119.

Soil

A sandy loam is generally considered the best soil for a nursery. A very heavy soil, such as the adobe characteristic of large portions of the forest regions of Arizona and New Mexico, is difficult to cultivate, and apparently is not conducive to the development of roots suitable for planting. Too much sand is also objectionable, because it does not retain sufficient moisture. The Fort Bayard Nursery is typical of the former type and the Gallinas Nursery of the latter. At the Fort Bayard Nursery an effort is being made to improve the soil by adding sand and organic matter in the form of barnyard and green manures. At the Gallinas Nursery clay is added in addition to organic matter.

Experience at the Fort Valley Experiment Station, where the soil is a sandy loam, indicates that there is danger of applying too much barnyard fertilizer, especially if not thoroughly rotted. A bed was treated with about 3 inches of old and fairly well rotted manure in the fall of 1910. On one-half of the bed it was spaded in, while in the other half it was placed in a layer 5 to 8 inches below the surface. The stock produced during the two years following was markedly inferior to that grown in adjoining non-fertilized beds. Apparently the decaying organic matter robbed the plants of the moisture in the soil, despite the fact that the bed was watered weekly. Undoubtedly the result would have been different in a humid region or where facilities for heavy irrigation are available. The best course is to apply only a moderate amount of manure and to grow a cover crop, preferably some leguminous plant, the first year. This should be plowed under early, so that it will rot thoroughly. If field peas, for example, are not plowed under until fall, the vines will be more or less woody and the time for decay will be insufficient, with the result that this material will interfere with transplanting.

Growing Space

There has been a tendency in the past to pay too little attention to the development of seedlings, the apparent assumption being that the development necessary to produce a good transplant takes place in the transplant bed alone. As a rule, the seedlings are too dense, especially when they are left in the beds until two years old. The characteristics of crowded seedlings are a slender form, with small crowns of few and short needles, and a correspondingly small root system. Western yellow pine in particular needs plenty of growing space. A seedling which has been dwarfed in over-dense beds or has developed a tall, weak stem and thin foliage through excessive artificial shading, crowding, or too much water enters the transplant stage under a handicap. A dwarfed seedling may recover under favorable conditions, but tall, spindling, thin-foliaged seedlings retain this undesirable form. Experiments indicate that western yellow pine second-year seedlings should not be denser than 75 per square foot. Watering will also increase the capacity of beds; but excessive watering should be avoided, because plants produced under such conditions would be poorly adapted to withstanding drought in the field. Douglas fir can be denser than western yellow pine, although no experiments have been made to determine definitely the number per square foot for this species. The number of seedlings which can be grown on unit area varies with the species, soil, climate, water supply, and other conditions. Therefore, rather than accept arbitrarily figures determined in other localities, this subject should be studied at each nursery.

Crowding in the transplant bed must also be avoided. Yellow pine should not stand closer than 1½ inches apart in the row, while a 2-inch spacing is better.

Water, Cultivation, and Protection

The care required varies considerably with location, soil, species, and time of sowing. If the nursery is located away from settlements, very little weeding will ordinarily be required during the first three or four years. If drill sowing is practiced, surface cultivation sufficient to keep a hard crust from forming is desirable. This cannot be done when the seed is sown broadcast. If the seed is sown in the spring, watering, mulching, and shading are necessary; if sown just before the beginning of the rainy season, water, mulch, and shade can be dispensed with to a large extent, at least for western yellow pine. Western yellow pine needs comparatively little shade and water after the seedlings are a month old. Douglas fir and Engelmann spruce, on the other hand, are sensitive to strong sunlight and drought. All species should be protected against frosts which are likely to occur toward the close of the growing season. The common lath shades usually furnish sufficient shelter until the beginning of the winter. At the Fort Valley Experiment Station the lath shades are put on all first-year seedlings about October 1 and left continuously through the usual clear, dry fall period. About November 15 all first-year seedlings are mulched even with the tops with pine needles. Experience at Fort Valley and at the Gallinas Nursery indicates that Douglas-fir transplants, as well as seedlings, must be covered entirely during the winter. This was strongly brought out during the winters of 1912-1913 and 1913-1914. Douglas-fir seedlings and transplants which were not covered were killed, and in covered beds wherever a top protruded through the needle mulch it was brown. The same results have been experienced with Engelmann spruce and exotics, such as Norway spruce, Austrian pine, and Jeffrey pine. The only care given second-year western yellow-pine seedlings is an occasional watering and raking. Douglas fir, Engelmann spruce, and most exotics require shade and abundant water in sunny weather, even in the second and third years. A safe rule to follow in regard to shading is to give only as much artificial shade as is necessary to prevent injury. This rule does not apply in the same degree to watering, because too little soil moisture, especially in western yellow pine, tends to develop an excessive tap root at the expense of the laterals; moreover, it may result in a distinct dwarfing not only of the top, but of the root as well.

FIELD PLANTING

In field planting the conditions which determine success or failure are less under the control of the forester than in nursery work. The areas requiring reforestation already exist. Their soil and climate cannot be changed appreciably by artificial means. The factors more or less under control are the choice of species, class of stock, season, and method of planting. Upon the forester's judgment in regard to these matters depends the success of his work.

Sites and Species

The best indication of the suitability of a site to a given species is the natural occurrence of the species on the site. Development, abundance, and the presence of other species in mixture serve to indicate closer distinction. For example, an area occupied by scattering, short-boled western yellow pine with more or less juniper or piñon, is to be regarded as less favorable for western yellow pine than a well-stocked area bearing long-boled, western yellow pine in pure stand or mixed with Douglas fir. The presence of natural reproduction is also to be regarded as a favorable sign. A dense growth of grass is undesirable; and short, turf-forming grasses, such as grama, usually indicate a drier, more compact soil than do the tall bunch grasses. The presence of live-oak brush, mountain mahogany, and sage-brush indicates drier sites than gambel oak or aspen.

One hundred 1½–1 transplants of good development were planted on each site in each year. With the exception of the limestone site, which is practically denuded, fairly good protection is afforded by old trees. An examination in the spring of 1914 showed that the planting on limestone sites both in 1912 and 1913 proved a complete failure. On rocky ridges with volcanic "malpais" soils about 78 per cent of the trees were found in good condition. On non-rocky flats with the same soil 39 per cent survived from the planting in 1912 and 87 from 1913 planting. On volcanic cinder soils, 37 and 58 per cent respectively. In the Douglas-fir type (granitic soils), 61 and 44 per cent respectively.

The results of soil moisture determinations on the same sites in 1912 follow:

TABLE 1.—*Soil moisture on planting sites*

Site.	Soil moisture, per cent of dry weight. Depth, 4–10 inches. Average of 3 samples.				
	May.	June.	July.	August.	September.
Yellow-pine type:					
1. Limestone soil	16.4	3.9	2.2	9.8	4.5
2. Volcanic "malpais" soil:					
a. Rocky ridge	22.7	13.8	6.8	19.3	10.4
b. Non-rocky flat	21.7	13.8	9.2	17.3	5.7
3. Volcanic cinder soil	......	4.3	4.9	17.4	5.8
Douglas-fir type:					
4. Granitic soil	......	15.3	10.8	12.5	7.2

Although counts on Site 1 show a fairly high percentage of live plants, success is uncertain. The losses appear to be due not to the inability of the plants to establish themselves, but to top injuries, which are mainly the work of grasshoppers, a tip-moth,[4] the May-beetle,[5] and rodents. Some damage also results from winter killing. These agents, excepting the May-beetle, seldom kill the plants outright, but destroy the new growth from year to year, so that at the end of three or four years, while counts may show as high as 80 per cent living, the trees are but little taller than when they were planted. That this area is capable of producing western yellow pine is evinced by old stumps representing stands equal to the best that are being cut in this region today. The present conditions are probably the result of destroying the forest, since the land is practically denuded for miles around. The light, calcareous soil dries out rapidly, but this is compensated, in a measure at least, by the fact that it has a low "wilting coefficient"—*i. e.,* only a small percentage of the moisture is non-available for growth. Probably the most serious condition resulting from deforestation is the establishment of a tall bunch grass (*Festuca arizonica*), which saps the soil and harbors a multitude of insects and rodents. To reforest such areas as this, it may be necessary to screen young plants and to eliminate grass competition by plowing or hand cultivation. The cost of these operations would be almost prohibitive.[6]

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[4] The species has not been determined, owing to the failure to find the insect in the adult stage. The eggs are deposited in the bud or young shoot. In June the larvæ are found to have hollowed out the shoot to such an extent that it breaks off.

[5] The larvæ of the May-beetle feed on the roots of the pine. Usually the entire root system is destroyed, with the result that the plant suddenly dries up. Frequently, however, only a portion of the root is devoured, and then the plant may persist in an unhealthy condition for several months, or may even recover.

Site 2 gives promise of good results. This site represents the optimum conditions for western yellow pine in the district. The area is on an old cutting on which about one-third of the original stand remains. The annual precipitation is about 24 inches. The soil contains a large proportion of adobe, which gives it a tendency to bake. It retains moisture well, but has a high "wilting coefficient"—*i. e.*, a high percentage of soil moisture is non-available for plant growth. Perhaps the worst condition here is the severe winters. In 1912-1913 much damage resulted from winter killing. The plants were not, as a rule, killed entirely, but the tops were injured. Very little damage of this character took place during the winter of 1913-1914. The larvæ of the May-beetle kill from 5 to 10 per cent of the plants during the first two years. The growing shoots are frequently injured by the tip-moth. A few plants are cut off or girdled by rodents. While the above agents may be expected to reduce the stock by from 30 to 50 per cent during the first five years, it is believed that with a spacing of 6 by 6 feet the survivors will be sufficient to form a good stand.

The main difference between the flats and ridges is in the presence of rocks. The flats are comparatively free from rocks, while the ridges are usually very rocky, and consequently the soil is less compact. The flats, on account of their situation, are more subject to frost than the ridges. Natural reproduction is generally most abundant on the ridges.

Site 3 is on a Forest Service cutting area in the lower limits of the western yellow-pine type. The subsoil is a heavy adobe similar to that of Site 2, but the surface soil to a depth of from a few inches to 2 feet or more contains a large proportion of volcanic cinders. Sometimes the surface layer consists of almost pure cinders, but usually they are mixed with more or less clay. The adobe subsoil retains moisture well, and where it can be reached by the roots planting is usually successful. On the whole, this site is drier than No. 2, partly on account of coarse soil and partly on account of lower precipitation. Very little winter killing has been experienced. With respect to damage by insects and rodents, Site 3 occupies a place between 1 and 2. The tip-moth is the worst enemy. Natural reproduction in the vicinity shows almost every plant up to 3 feet in height to have been injured by this insect; but observations indicate that a large proportion will finally recover. The losses on this site will be greater than on No. 2, but there is good reason to believe that planting will be successful.

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[6] Assistant District Forester Woolsey is authority for the statement that in Algeria the damage from rodents and drying out was much more severe where the brush and grass were only partially cleared. As a direct result of past losses the French are now usually removing all herbaceous and brush growth from planting sites, notwithstanding the additional expense.

Site 4 is an old burn, where the remaining stand consists of western yellow pine, Douglas fir, and limber pine. Aspen has grown up in dense thickets; but the yellow pine was planted in the openings where little or no aspen occurs. The precipitation is about 30 inches, or 6 inches more than on the best sites in the pure yellow-pine type. The soil is of granitic origin and contains more humus than is found in the yellow-pine type. Very little loss from winter killing and insects has been experienced. Gophers do more or less damage by digging up or covering young plants. The comparatively poor results on this site are due mainly to the fact that since the planting season is from two to three weeks later than in the yellow-pine type where the stock is grown, the stock must be held in storage to prevent growth. However, the second season's growth, together with the development of native trees on the area, indicates that western yellow pine will do fully as well here as on the other sites.

Perhaps the most difficult sites attempted in District 3 are the old yellow pine-juniper cut-over areas on the Cameron Creek watershed of the Gila National Forest. Moisture conditions here are less favorable than in the pure yellow-pine type. The reforestation of this watershed was undertaken by the Fort Bayard Nursery in 1906. Western yellow pine is the main species used, although Jeffrey pine is promising. Alligator juniper and piñon ought to succeed here, but on account of slow growth and low commercial value they are not desirable. Arizona cypress is exceedingly promising on north slopes. The plantings prior to 1911 are largely failures due mainly to the use of poor stock. The results of experimental planting on various sites made in late winter with 2–1 stock, in 1912 and 1913, are as follows (last examination was made in November, 1913): On open, level mesa 80 per cent survivals from 1912 planting and 75 per cent from 1913 planting; in oak brush on south and southeast slopes, 71 per cent as a result of 1912 operations; on west slopes 58, and on steep north slopes 52 per cent (planted in 1913).

The comparatively poor results on the north slopes are due partly to the fact that the stock had been dipped in kerosene emulsion to kill aphids. Another probable cause is the fact that, owing to the frozen condition of the soil on the north slope at the time the other sites were planted, it was necessary to heel-in the stock for several weeks before planting. This condition must usually be reckoned with in planting north slopes. One of the best plantations on the Cameron Creek watershed is an area of about five acres planted in January, 1911, on a southeast slope in moderately dense oak brush. Fully 60 per cent are in thrifty condition at the present time. An area of 70 acres, taking in various sites excepting north slopes, planted in January and February, 1914, is at the present writing a complete success.

The Douglas fir and Engelmann spruce planting areas are mainly on old burns above 8,500 feet elevation. Two general conditions occur, namely, aspen-covered and open areas. All observations thus far indicate that the aspen-covered areas are most favorable. The shade of the aspen checks excessive evaporation, but is not ordinarily dense enough to injure young Douglas fir or Engelmann spruce. In heavy aspen stands it may pay to thin the nurse trees after the conifers are from 8 to 10 years old. There is generally little difference between the soil moisture content of aspen-covered and open plots. While evaporation from the ground is lower in the aspen stands, this is offset by the consumption by the aspens themselves. The results of two years' experimental planting with Douglas fir at the Fort Valley Experiment Station, as shown by last examination in June, 1914, are: 31 per cent in good condition in the open and 47 under aspen cover (1912 planting); 38 per cent in the open and 74 under aspen (1913 operations).

The stock in 1912 was poor and in 1913 fair. All of the planting was done in early spring.

In all planting it is important to take advantage of local ground features, such as slight depressions, the shelter of stumps, logs, or bushes, and spots where competition from other vegetation will not be excessive.

Season for Planting

Spring, summer, fall, and winter planting have been tested with practically all species used. The experiments point conclusively toward the superiority of early spring or, in some cases, late winter planting. Summer planting makes it possible to take advantage of the summer rainy period, when conditions for growth are optimum; but the disadvantage of summer planting is that trees at that time are in a growing condition and therefore suffer more from the shock of transplanting than at other times. The most common difficulty with fall planting is that the tops are subject to drying out during the winter, especially on sites which do not remain snow-covered. Another form of injury on heavy soils is frost heaving. In the yellow-pine type the soil is often too dry for planting in the fall. Winter planting is practical only where the ground does not stay frozen during long intervals. At the Fort Bayard Nursery western yellow pine is now generally planted late in January or February on the warmer sites. The advantage of spring or late winter planting is that the roots are in the ground at the first beginning of growing weather, while the tops are not exposed unduly long, as in the case of fall planting. In order to survive the long rainless period of May, June, and early July, it is important that the roots become established before the severe drought sets in. The soil is usually well saturated in early spring, but it grows steadily drier until the drought is broken by the summer rains in July. Plants which are set out as soon as the frost is out of the ground have from a month to six weeks of comparatively cool weather and abundant soil moisture in which to become established before the extremely dry period begins. If planting is delayed, the period for establishment is correspondingly shortened.

The above conditions are somewhat modified in northern New Mexico and in the higher altitudes of the entire two States, where the early summer dry period is less pronounced. Douglas fir has been planted in July and August, at altitudes of 9,000 to 10,000 feet, on the Coconino, Pecos, and Crook National Forests with a fair degree of success; but the results generally are in no wise comparable with those of early spring planting.

It may be stated as a general rule that for all species in Arizona and New Mexico the best time to plant is as early in the spring as the condition of the soil permits. The actual date may vary from January 15 on the lower southerly exposures to June 15 in the high mountains, where the snow persists late into the summer. If it becomes necessary to plant late in the spring or during the summer, the best possible sites, preferably near the upper altitudinal range of the species, should be chosen. For late spring planting it is advisable to hold back the growth of the stock as much as possible. This can be accomplished by heeling-in along a snow-bank in a protected situation at a high altitude. Experience has shown that stock cannot be kept in this manner much later than June 1. In summer planting the operations should be deferred until the soil has been moistened to the depth reached by the roots.

Stock

Several age-classes of stock have been used. In the following pages the designation indicates the number of years in seed bed and transplant bed. Thus 2–1 stock means plants which were grown two years in the seed bed and one year in the transplant bed.

Table 2 shows the development of western yellow-pine stock planted at the Fort Valley Experiment Station in 1913. Table 3 shows the results of planting in 1912 and 1913. The planting was on typical western yellow pine cut-over land at an altitude of 7,300 feet. One hundred plants of each class were used.

TABLE 2.—*Development of different classes of western yellow-pine stock*

Class.	Length (inches).		Character of root.
	Top.	Root.	
1½ seedlings	1½–2	6–8	Moderate lateral development.
1½–1 (first) transplants	2–3½	10–12	Good lateral development.
1½–1 (second) transplants	2–3	8–10	Similar to first class, but smaller.
½–1–1 transplants	3–4	10–12	Bushier than 1½–1 first class.
½–2 transplants	4–7	10–14	Good lateral development, but coarser than the other stock.

TABLE 3.—*Results of different classes of western yellow-pine stock at the Fort Valley Experiment Station*

In good condition May, 1914 (per cent)

Class of stock.	Planting of—	
	1912.	1913.
1½–0	32	36
½–1–1	37	65
1½–1 (first)	44	87
1½–1 (second)		55
½–1	39	......
½–2	55	55

All the 1912 planting suffered severely from winter killing during the winter of 1912-1913. Some plants died from the effects; others remained alive but without leaders, while others fully recovered. Comparatively little injury was suffered during the winter of 1913-1914.

The larvæ of the May-beetle did considerable damage on some plots. The pine tip-moth also did more or less damage by killing the leaders. Of the 1912 plants now classed as living, from 10 to 25 per cent have dead leaders.

The ½–2 stock planted in 1913 dried up considerably in the tops during the dry foresummer. This is attributable primarily to the long stem (4–7 inches). On November 6, 1913, only 70 per cent of this stock was in perfect condition against 95 per cent of the 1½–1 stock. In 1912 the ½–2 stock was much shorter than the same class in 1913, which accounts for the good results in 1912 planting of this stock.

It seems to be quite conclusively established that the use of 1½-year seedlings is not advisable. A number of 2½-year seedlings thinned in the seed beds to approximately the density of transplants were field planted in the spring of 1914. This stock is expected to give better results than the 1½-year seedlings, although the root development is decidedly inferior to that of 1½–1 transplants.

Twice transplanted stock is too expensive, due to the extra cost of the second transplanting. The only case in which the use of this class of stock may be justified is when culls are placed in the transplant bed a second time instead of being thrown away.

First-class transplants, judging from the results of the 1913 planting, yield distinctly better results than second-class transplants. Whether it will pay to cull all plants of inferior development depends upon the site, the season, and the percentage of such plants in the stock. Ordinarily, if the stock runs 80 per cent or more of firsts, it will not pay to cull any except the very poorest plants. If, however, the stock runs as low as 40 per cent firsts, it will pay to cull the inferior plants and either discard or transplant them a second time. The data at hand are inadequate for definite statements as to when the latter action is advisable. The best solution of the problem is to grow stock with a high percentage of good plants.

The 1½–1 stock will probably prove the most economical in northern Arizona. While ½–2 transplants sometimes give good results, they are generally too large to withstand field planting well.

The results with different classes of western yellow pine at the Fort Bayard Nursery, planted in January and recounted in November, 1913, are as follows: 2–1 stock gave 37 per cent of survivals; 1–1 stock, 29; 1–1–1 stock, 27. The planting was on a brush-covered south slope of about 10 degrees—a very difficult site. Each class is represented by 200 plants.

On the whole, the best results with western yellow pine at the Fort Valley Experiment Station and the Fort Bayard Nursery have been obtained with 2–1 or 1½–1 stock. The difference between 2–1 and 1½–1 stock is that in the former class the seed is sown in the spring, while in the latter it is sown in July or August. Thus 2–1 stock is produced from seedlings which have had two full seasons in the seed bed, while 1½–1 stock is produced from seedlings which have had only 1½ years in the seed bed. Excepting in regions of very short growing season, 1½–1 stock is preferable, since the 2–1 stock is generally too large to handle economically. In regions of long-growing season it may be possible to produce 1–1 stock of good development, although experience at the Fort Bayard Nursery has been to the contrary.

Table 4 shows the character of different classes of Douglas-fir stock planted at the Fort Valley Experiment Station in 1913. The results in June, 1914, of planting in 1911 and 1913 are as follows: 1–2 Gallinas stock, 60 per cent (1911 planting); 1–1–1 local stock, 71 per cent (1911 planting); 1½-year seedlings, local stock, 38 per cent (1913 planting); 3-year seedlings, Frye Canyon Nursery stock, 45 per cent (1913 planting); 2–1 transplants, Gallinas Nursery stock, 73 per cent (1913 planting); 1–2 transplants, local stock, 68 per cent (1913 planting). The planting was on an aspen-covered burn in the Douglas-fir type at an altitude of 8,700 feet. One hundred plants of each class were used in each year's test.

TABLE 4.—*Development of Douglas-fir stock*

Class of stock.	Source.	Length (inches).		Character of root.
		Top.	Root.	
1½-year seedlings..	Fort Valley Nursery.	1–2	4–5	Short but well developed.
3-year seedlings...	Frye Canyon Nursery.	6–8	6–8	Fair.
2–1 transplants....	Gallinas Nursery.	1–2	4–5	Short but well developed.
1–2 transplants....	Near planting site.	1½–2½	5–6	Fair.

It is evident that very small seedlings, such as the 1½-year stock planted in 1913, are not suitable for field planting. On the other hand, extremely large stock is also undesirable. Observations in both 1912 and 1913 plantings indicate that the plants with very long tops suffer worst. While transplants will generally give the best results, it is believed that Douglas-fir seedlings of medium size (4 to 5 inches tall) can be planted successfully on favorable sites.

In all species age-class should be taken as a criterion only in so far as it indicates certain qualities. Generally 1½–1 or 2–1 western yellow pine transplants have the best root system and the best proportion between root and top, but sometimes 1–1 or 1–2 stock shows good development and yields practically the same results. In Douglas fir the best development is usually found in transplants, but seedlings are often sufficiently good to warrant their use.

Methods

The difficult conditions under which the establishment of trees takes place in the Southwest demand the use of careful methods. Because of the large root systems necessary to insure success in planting, fairly large holes must be dug. The roots must be spread out in a natural position and the soil firmed around them. The necessity for good planting is obvious when it is considered that immediately after the trees are set out they must withstand a period of two or three months with practically no rain. The quick methods sometimes used in regions of abundant rainfall, as, for example, where a plant with a short straight root is inserted in a slit made with an axe or spade, are out of the question in the Southwest.

In determining the size of planting holes necessary it was assumed at the outset that the depth must be equal to the length of the root and the width sufficient to permit the roots to be spread out in a natural position. The benefits sought in the use of extremely wide holes up to 12 inches or more are those usually resulting from cultivation, namely, improving the condition of the soil and eliminating competing vegetation. This principle was carried to the extent of spading up spots 2 feet in diameter a year before planting.

In the fall of 1910 a number of spots 18 to 24 inches wide were spaded to a depth of 12 inches. At the same time a number of holes 18 to 24 inches in diameter and 12 inches deep were dug and left open through the winter. The following spring western yellow-pine and Douglas-fir transplants, all excellent stock, were planted in the prepared spots and holes, and also in holes 6 to 8 inches in diameter dug in the virgin soil at the time of planting. In the spring of 1912 additional plots were planted, comparing holes 5 to 6 inches wide with holes 10 to 12 inches wide, all dug at the time of planting. The results for yellow pine (last examination in May, 1914) may be summarized as follows: In prepared spots on "malpais" soil, 38 per cent in good condition; on limestone, failure; in holes open over winter on "malpais" soil, 33 per cent; in holes dug at time of planting, 48 per cent on "malpais" soil and failure on limestone soil; in holes 5 to 6 inches in diameter, both on "malpais" soil, 40 per cent; in holes 10 to 12 inches in diameter, 40 per cent (1912 planting). The 1913 planting gave for the smaller holes 97 per cent of survivals and for the larger holes 91 per cent.

For Douglas fir the difference in the preparation of the soil did not result in marked difference in the per cent of survivals, being on an average close to 55.

The 1911 and 1912 plantings of western yellow pine suffered from winter killing in 1912-1913. This accounts in a large measure for the low percentage of plants in good condition. Many of the injured plants will doubtless recover.

The 1911 plantings show in the case of Douglas fir a distinct advantage of holes left open over winter, but no advantage is apparent in western yellow pine. There seems to be no advantage in prepared spots. The reason for the failure of additional cultivation to yield results is probably that the area cultivated was not large enough to eliminate root competition from surrounding vegetation. Soil samples show only a very slight excess of moisture in the cultivated spots as compared with uncultivated soil. Spots 3 or 4 feet in diameter would doubtless show a decided difference, but the cost would under ordinary circumstances be prohibitive. The cost of preparing spots is from $1 to $3 per hundred. This previous preparation facilitates planting in the spring, but the total cost of the planting operation is at least doubled. The cost, using holes 10 to 12 inches in diameter dug at the time of planting, is about 20 per cent higher than for holes 5 to 6 inches in diameter.

The results of these experiments indicate that the increased cost of preparing spots or digging holes wider than necessary for good planting is not warranted under usual circumstances.

The following planting methods have been tested:

1.—*"Side-hole" method.*—Roots spread out against the side of the hole. The advantages of this method are simplicity and speed. The main objection raised is that the roots are placed in a flat layer against the hard bank on one side of the hole.

2.—*"Cone" or "Mound" method.*—A cone or mound of fresh earth is formed in the middle of the hole. The plant is set at the apex of the cone, with the roots spreading on all sides. The advantage claimed for the method is that the roots are distributed better than by other methods. A disadvantage is that it is slow and difficult of execution by inexperienced men. The method is not adapted to stock with a poorly developed system of laterals.

3.—*"Middle-of-hole" method.*—The plant is placed in the middle of the hole, somewhat lower than its ultimate position, the roots being spread out on the bottom. As the soil is thrown in the plant is gradually raised to the proper elevation. The advantage claimed for the method is that in raising the plant after the first soil is thrown into the hole, thus drawing the lower portion of the root system through the loose soil, the roots are straightened out. It requires somewhat more time than the "side-hole" but considerably less than the "cone" method.

The results with western yellow pine planted by different methods at the Fort Valley Experiment Station are briefly as follows:

The 1912 planting gave for the "side-hole" method 24 per cent of survivals; "cone" method, 48, and "middle-of-hole" method, 39. The 1913 planting showed 83, 77, and 73 per cent survivals respectively for the three methods. The stock used was 1½–1 old and the observations were made in May, 1914.

For Douglas fir the 1913 planting gave for the "side-hole" method 74 per cent of survivals in June, 1914; for the "cone" method, 72; for the "middle-of-hole" method, 58.

None of the three methods shows consistent superiority over the others. In the 1912 planting of western yellow pine the "side-hole" method shows poor results, but in the 1913 planting it compares favorably with the other methods. In Douglas fir the "side-hole" method holds first rank. All of the 1912 yellow-pine planting suffered severely from winter killing, with the result that a high percentage have no definite leaders.

The results secured at Fort Bayard Nursery are more conclusive than those obtained at the Fort Valley Experiment Station.

In 1912 planting the "side-hole" resulted in 73 per cent living in November, 1913, and the "cone" method in 78.

In 1913 planting the "side-hole" gave 56; the "cone," 67, and the "middle-of-hole" method, 61 per cent living in November.

The order of merit for the three methods is: "Cone" method, "middle-of-hole" method, and "side-hole" method.

The time required to plant 100 western yellow pine by the various methods on heavy, more or less rocky soil, according to records at the Fort Valley Experiment Station in 1913, reduced to a 1–man basis. is as follows: "Side-hole" method, 3 2/3 hours; "cone" method, 6 2/3 hours; "middle-of-hole" method, 4 2/3 hours.

At the Fort Bayard Nursery the cost of the "cone" method is estimated 50 per cent higher than the "side-hole" method.

Reducing the results of the 1912 western yellow-pine planting at Fort Valley to the basis of cost per thousand living plants, placing labor at $2.50 per day and stock at $4 per M, the results at the close of the year 1913 are as follows: "Side-hole" method, $21.76; "cone" method, $27.58; "middle-of-hole" method, $21.26.

A similar comparison for the 1913 planting would be premature at this time.

In choosing between the three methods the "cone" method may ordinarily be eliminated as too expensive. It costs considerably more than the "middle-of-hole" method and gives but little better results. Between the "side-hole" and "middle-of-hole" methods there is a slight margin in favor of the latter in western yellow pine. The choice between these two methods should be governed more or less by circumstances. When it is necessary to employ inexperienced planters, the "side-hole" method will generally prove superior, because with this method there is less danger of bending the roots and of too deep or too shallow planting. On difficult sites the "middle-of-hole" method is surer of success. On the whole, choice of method is of less importance than efficient work and an understanding of the needs of the tree by the planter.

Costs

No reliable data on the cost of planting in District 3 are available. Since all of the planting has been on a comparatively small scale, overhead charges and cost of supervision have been unduly high. This applies particularly to nursery work. It is reasonable to assume that if circumstances should in the future warrant the establishment of large nurseries planting stock can be produced about as cheaply here as in other districts. At the Gallinas Nursery, where cheap Mexican labor is available, Douglas fir and Engelmann spruce have been planted at from $12 to $15 per acre. At the Fort Bayard Nursery, where western yellow pine is the principal species, where labor is comparatively high, and where careful work is necessary, the cost has been about $30 per acre. It is estimated that in large-scale operations the cost for western yellow pine will be from $15 to $25 per acre, and for Douglas fir and Engelmann spruce from $10 to $15 per acre, spacing 6 by 6 feet.

THE FUTURE OF ARTIFICIAL FORESTATION IN DISTRICT 3

The experiments cited in the preceding pages indicate that planting can, with the possible exception of certain sites—as, for example, large clear cuttings which have grown up to grass—be successfully accomplished in this region. The oldest experimental plantations are now in their fourth season. They show from 50 to 75 per cent of the plants living, but an average of from 10 to 20 per cent of these have top injuries resulting from insects, winter killing, and rodents. It is evident that a considerable loss must be expected before the plants are fully established. The same mortality is found in natural reproduction. Several sample plots were established on the Coconino in western yellow-pine reproduction from two to four years old in 1908 and have been examined yearly. One plot 50 by 100 feet containing 95 seedlings in 1908 had 18 alive in 1913, and of these only eight were in good condition. In another plot, out of 66 in 1908, 50 remained in 1913, and not one of these had a good top. These results are less discouraging when it is borne in mind that despite serious setbacks good stands are being established naturally, even on the most adverse sites. Many of the seedlings which now have dead terminals will doubtless recover and eventually develop good form. This opinion is supported by the fact that thrifty saplings up to 8 or 10 feet high almost invariably show pronounced bends in the lower part of the stem, indicating repeated top injuries in the past. It is common to find extensive areas of good reproduction in which almost every seedling below 3 feet high has top injuries resulting from the work of the tip-moth. Plantations will undoubtedly have to go through the same trials as are encountered by natural reproduction. Here a group will be injured by insects, while there a group will be entirely killed by the larvæ of the May-beetle. Large areas may lose half their trees during an unusually severe winter or dry spring. Some of the plantations will be irregular, perhaps requiring replanting; others, having the advantage of good sites and favorable seasons during the period of establishment, will be successful in one planting. In view of the heavy losses which must be expected, a spacing not wider than 6 by 6 feet is recommended.

Artificial reforestation will not generally be financially attractive in the Southwest, but it will nevertheless occupy an important place in the management of National Forests in this region. In discussing conditions under which artificial forestation is feasible it is necessary to distinguish between commercial and protection forests.

Commercial planting, because of the slow growth and the high cost of planting in the yellow-pine type, where the bulk of the merchantable timber occurs, will be limited to certain conditions. Limited areas denuded by heavy cutting will require planting to establish a stand. Returns from these plantations will not equal the cost of planting during the first generation. But when it is considered that after the stand is once re-established it will under proper treatment maintain itself by natural regeneration, the artificial reforestation of denuded timber lands seems to be a practical undertaking. On portions of our sale areas complete reproduction will not take place within a reasonable time after cutting. Under such conditions the planting of blanks to supplement natural reproduction may be warranted. The policy of cutting large mature trees and devoting the proceeds of their sale to planting when necessary rather than leaving them as seed trees at the risk of loss through windfall, lightning, or decay is advocated by many foresters. A characteristic arrangement in the yellow-pine forests is the occurrence of very heavy stands, yielding from 20,000 to 30,000 board feet per acre, in small flats, narrow valleys, or canyon bottoms, with open and usually short-boled stands on the adjoining ridges. The timber on the flats and bottoms is tall and often over-mature, so that frequently it is impossible to find an adequate number of suitable seed trees. On such sites it would be feasible to cut all the over-mature timber and plant where the cutting would leave an insufficient number of trees to secure natural reproduction.

On nearly all of the high mountain watersheds of the district burns of considerable extent are to be found. The greater portions of these burns are restocking; but there are thousands of acres in the Douglas-fir and Engelmann-spruce types which, owing to a lack of seed trees, cannot be expected to restock within two generations. Many of these areas are being occupied by grasses, and after a continuous turf is established it is doubtful whether the trees will ever regain a foothold without assistance from man. The value of high mountain forests for water protection renders it important that denuded areas be reforested. Moreover, these areas will produce stands of from 20,000 to 30,000 board feet per acre, and therefore planting may be warranted even from a strictly commercial point of view. Undoubtedly these high mountain burns offer the best field for planting in District 3.

SUMMARY

1. Reforestation by direct seeding is believed to be impracticable in District 3. Planting, on the other hand, promises to be successful.

2. The failure of the early attempts at field planting is due mainly to the use of poor stock.

3. In order to withstand field planting, the young tree must be able to maintain a safe balance between water absorption and loss. To do this, it must have a root sufficiently long to reach into the soil strata which retain considerable moisture through protracted dry periods; the root system must have laterals which will enable it to draw from a comparatively large soil mass; the roots must be provided with an abundance of active fibrous rootlets; and, finally, in order to avoid excessive transpiration, the top must not be too large.

4. The following conditions are required for the production of good planting stock:

a. Good seed. The seed should be of high germinating power, and it should be from trees of good form and development, indigenous, or from a locality whose soil and climate are similar to those of the region in which the seed is to be used.

b. Suitable soil. A rich sandy loam, neither too sandy nor too clayey, is preferable.

c. Sufficient growing space in the seed bed as well as in the transplant bed.

d. Sufficient water to produce a vigorous growth, but not so much as to make the plants excessively large and susceptible to drought, nor so little as to result in dwarfing.

e. Protection against sun, wind, and frost sufficient only to avoid injury.

5. The selection of species for a site should be governed primarily by the occurrence and development of the species growing on the site. Ground cover or underbrush may be used as a further index.

6. The best time to plant any species in Arizona and New Mexico is as early in the spring as the soil can be worked, and in any event before the stock has begun growth.

7. In western yellow pine the best stock has generally been found in 1½–1 or 2–1 transplants; seedlings have given poor results. In Douglas fir the best development is secured in 2–1, 1–2, or 2½–1 transplants, although three-year-old seedlings have given good results on favorable sites. Age-class should be taken as a criterion only in so far as it indicates desirable qualities.

8. No appreciable advantage has been experienced in the use of holes wider than necessary for good planting, nor in the use of prepared spots. These devices add greatly to the cost of planting.

9. The differences between the "side-hole," "middle-of-hole," and "cone" methods are not very striking. Considering cost as well as results, the choice lies between the "side-hole" and "middle-of-hole" methods. On the whole, the choice of method is of less importance than careful work and an understanding of the requirements of the plant.

10. Artificial forestation is destined to occupy an important place in the management of National Forests in District 3. The best field for planting is in the high mountains, where heavy stands can be produced and where the forest has a value for watershed protection in addition to its timber value. Commercial planting in the western yellow-pine type will ordinarily be limited to the reforestation of denuded areas and the restocking of blanks where natural reproduction is deficient.

In conclusion, it is well to bear in mind that our planting and nursery practice can never be reduced to a matter of rules. If no unexpected reverses are met in the next two years, we will have reached a point where it is safe to proceed on a larger scale. But this does not mean that the reforestation problem will be disposed of. Set-backs will undoubtedly occur as a result of infestations, abnormal seasons, and unusual site conditions. Moreover, there will always be room for improvement in methods. These conditions make it imperative that the men in charge of our nursery and planting operations be scientifically trained, practical, and alert like the modern farmer and business man.

CUTTING WESTERN YELLOW PINE IN ARIZONA AND NEW MEXICO

BY THEODORE S. WOOLSEY, JR.

Contributed

THE PROBLEM

In Volume VII, No. 2, of the Proceedings of the Society of American Foresters, Earle H. Clapp described the "Silvicultural Systems for Western Yellow Pine." This article was written after thorough discussions with most of the professional foresters in the Washington office of the Forest Service, and was only published after being referred to each of the six districts for criticisms and suggestions. Therefore it is with some temerity that the writer will attempt to show that Mr. Clapp's statement contains some technical and practical mistakes.

He states:

> "Using as a basis the moisture or shade conditions necessary to secure natural reproduction, yellow-pine stands may be divided into three classes, each of which should be handled differently.
>
> 1. A comparatively large portion of the yellow-pine region in which moisture and other conditions are so favorable that natural reproduction is reasonably certain, even though cutting is not designed primarily to secure it. Here a modification of the selection system in which small groups are treated much the same as individual trees should be used.
>
> 2. A smaller proportion of the yellow-pine region, including drier portions of the Southwest, parts of California, where the chaparral question is serious, and possibly the pumice soils of the eastern Cascades, in which, in spite of adverse moisture and temperature conditions or the presence of brush, it is reasonably certain that natural reproduction can be secured by careful cutting. The method of cutting must accordingly be designed almost altogether by preserving favorable moisture conditions or by shading out chaparral, or both, to secure reproduction. The trees left must be as evenly distributed over the area as other conditions will allow. Since full light is necessary for the thrifty growth of saplings, the parent trees must be removed as soon as possible after reproduction is secured, resulting in a primitive application of the shelter-wood system, even-aged stands, and the possibility of much greater volume production than at present.
>
> 3. Areas of considerable extent in exposed situations and along the lower border of the type, where conditions are extremely adverse and where natural reproduction cannot be expected to follow any system of cutting. No cutting should be done until advance reproduction is pres-

ent, and it should then take the form, either selection or clear cutting, which the quantity and distribution of the advance reproduction indicates."

The problem will be discussed under the following headings:

1. Strictures on Clapp's arguments.
2. Are "systems" now necessary?
3. The theory based on results of European practice (India, Corsica, France (Provence), Russia).
4. Past practice in the Forest Service.
5. The solution today.
6. Tabular summary.

1. STRICTURES ON CLAPP'S ARGUMENTS

In regard to details, Mr. Clapp's article, in my opinion, contains a number of inaccuracies. (*a*) Page 169, Mr. Clapp refers to the selection system where "approximately two-thirds of the volume of the merchantable stand has been removed." I believe that this "selection system" is a misnomer, but for the sake of uniformity the writer will follow the same terminology. (*b*) In the résumé of Mr. Pearson's conclusions (page 172) Mr. Clapp gives the impression that reproduction in Arizona and New Mexico is, on the whole, very poor. I do not feel that this is altogether the proper impression to leave. In the area near Flagstaff under intensive study by Mr. Pearson (a small part of the Coconino Forest) this is no doubt true; but, taking the district as a whole, yellow pine produces rather better than might be expected under the adverse climatic conditions. While the reconnaissance figures are not exact, they cover considerable areas systematically; the reproduction has been classified as fair, good, or poor on the following basis:

Good reproduction means that seedlings already stock at least 65 per cent of the area; fair reproduction, that seedlings are scattered, but sufficient to restock 30 to 64 per cent of the area, and poor reproduction, that new growth is entirely lacking or so incomplete that less than 30 per cent of the area will be restocked.

A summary of the reports on the Forests listed below gives the approximate percentage of the regeneration thus classified:

Forest.	Character of reproduction (in per cent).			
	Good.	Fair.	Poor.	Park (open), etc.
Carson	27	22.5	18.25	32.25
Coconino	30	27.5	34	18.5
Gila	49	34	17	.....
Sitgreaves	41.8	33.5	24.7	.....
Tusayan	20	25	33	22

If these figures can be taken as approximately correct (they are by no means exact), they signify that natural regeneration is already present on more than half the forested area. They include a small percentage of Douglas-fir land, to be sure, but with management and protection regeneration should be reasonably certain on at least half the area. We must wait for a good seed crop followed by favorable climatic conditions. It is significant, however, that much of this young growth has come under conditions which closely approach those found in a forest managed by the selection system.

(*c*) On page 174 Mr. Clapp states that where conditions are adverse "no cutting should be allowed until advance reproduction is secured." This means ordinarily that there would be no cutting at all. What should be done, and what I believe is the practice in Europe, is to practically disregard the quality of reproduction on these exposed situations as the determining factor and merely take out the diseased, dead, and dying trees in light improvement cuttings. Even if reproduction by some chance should come in quite completely—an unlikely occurrence—a heavy cutting would never be sanctioned, and (*d*) even where planting is practicable these exposed sites would never be clear cut and planted as advocated by Mr. Clapp. On page 175 he states:

> "After planting methods have been developed, it will, of course, be possible to cut clear and plant."

It seems to me it would be the height of folly to ever think of clear cutting at the lower limits of the western yellow-pine type in Arizona and New Mexico. Even if any planting were feasible, it should be before, not after, logging. Aside from the fire risk such plantations would be subjected to, which would be tremendous, to expose a soil already dry, without even the protection of an open stand, to the full influence of the sun and wind would be actually endangering this type of forest; it is poor practical forestry and poor technical forestry. Where a light cutting is impracticable there should be no logging at all. (*e*) On the same page Mr. Clapp states:

> "In stands where the percentage of yellow pine is small, even though it is unquestionably the best species, the inferior species, or those of secondary importance, should not, unless other silvicultural reasons make it necessary, be cut heavily except when by so doing it is reasonable to suppose that the percentage of yellow pine can be increased."

The force of this argument is not clear. Suppose, in a mixed stand of Douglas fir, yellow pine, and white fir, that the white fir was very overmature, even if the percentage of yellow pine could not be increased by heavily cutting the white fir, this heavy cutting of an inferior species, now fully ripe and merchantable, would certainly seem to be the proper procedure, particularly as in those situations there is usually advance reproduction. Even if this advance growth were white fir, there seems to me to be no doubt that the proper move is to uncover it. Who can say what species now considered inferior will be worth in the year 1975?

2. ARE "SYSTEMS" NOW NECESSARY?

The whole aim of Mr. Clapp's article seems to be to establish silvicultural systems for western yellow pine. He apparently takes the ground that the Forest Service has made a mistake because it is cutting its western yellow pine without a silvicultural system in view. Is this line of argument (with respect to western yellow pine) at this period of our forest administration either reasonable or tenable? In the first place, can we predict what silvicultural system will be advisable twenty or fifty years from now? It will undoubtedly depend on the results of our past cutting and on the market conditions which shall exist. For the Forest Service to make extensive improvement cuttings in all its irregular western yellow-pine stands as rapidly as possible, in order to remove the overmature timber, seems to me to be good silviculture, good management, and entirely practicable; later perhaps we can define our systems. As a matter of fact, Mr. Clapp himself probably could not distinguish in the field between the average western yellow-pine stand in Arizona and New Mexico which was cut over by the selection system—*i. e.*, where two-thirds is removed—and a "primitive application of the shelter-wood system." It would be mere guess work. In other words, the great fundamental principle which should underlie a marking in western yellow pine is to get rid of undesirable trees and give the purchaser a chance to make a livelihood. By this class of trees I mean trees that are overmature, trees that are crooked, trees that are attacked by insects or fungus, stag-headed trees, trees with sickly foliage, and those which are evidently on the decline. Let us leave the determination of the silvicultural system for the irregular virgin stands of western yellow pine until we may base our decision upon the results of our cuttings. No matter what the final system is to be, our present methods would not vary if we dispose of overmature timber and free regenération which already exists.

The "systems" discussed by the writer are therefore purely theoretical.

3. THE THEORY BASED ON RESULTS OF EUROPEAN PRACTICE

It undoubtedly is of interest to the profession to discuss this problem from a purely theoretical standpoint without reference to immediate practical conditions. We have the results of cutting pine in other countries to draw from.

India.—In the chir pine forests of the Himalayas the Indian forest service has employed various systems. An article by E. A. Smythies (*see* Indian Forester, No. 11, Vol. 29) discusses the problem in the light of past experience:

It should be understood that chir pine grows in fairly even-aged clumps and reproduces rather more readily than does yellow pine at the most favorable elevations; but, of course, these groups are irregularly dispersed.

At Naini Tal the selection system ("usually forced into the selection-in-group system") has been tried out for 25 years. The chief objections have been: difficulty in freeing reproduction sufficiently; impracticability of using selection cuttings in even-aged stands. At Ranikhet, under the uniform system (shelter-wood), three fellings were prescribed at intervals of seven to ten years—a first, second, and final felling. Smythies states: "* * * one is forcibly struck with the magnificent success in some areas and abject failure in other areas. * * * Without exception, success has followed in areas with mature umbrella-shaped trees, failure in areas of immature spear-shaped trees." This has resulted in the establishment of regeneration "anywhere and everywhere except where it should be," but as Smythies remarks, "Any method of transforming our existing haphazard forests into a perfect and normal forest is bound to involve sacrifice"—a strong argument against its use. Mr. Smythies continues:

"We come now to a consideration of numerous problems. Let us begin by summarizing the results we have so far arrived at:

(1) Sowing of chir pine, given protection from fire and grazing, will succeed under the most unfavorable conditions. *Ergo,* we should have no difficulty in achieving success with natural regeneration.

(2) No shelter-wood is required for chir reproduction. It is hardy against drought, frost, etc., and its light-demanding nature makes it succeed best in the open. Chir reproduction will, however, establish itself under the moderate shade of a mature and open crop.

(3) Mature trees will give sufficient seed for successful natural regeneration, immature trees will not.

(4) Our existing forests are usually found to be made up of even-aged groups, some will be mature groups, and some immature. Extensive forests of uniformly even-aged trees are the exception.

(5) Given the necessary protection, chir regeneration will spring up under all mature and open groups; it will be absent under immature groups.

Let us see how these characteristics affect or influence our choice of system for the management of our forests. All possible systems come under one of the three main heads:

(1) Clear-cutting systems.
(2) Regeneration in periodic blocks.
(3) Selection systems.

These must be considered separately.

The clear-cutting systems, of course, gives us the normal forest in the shortest time, and if the silvicultural requirements of the pine alone were to be considered such a system would probably be indicated. But in the present state of our forests any clear-cutting system would involvé an enormous sacrifice of immature trees, artificial sowings in the neighborhood of the immature groups would have to be resorted to, and, so far as I know, clear-cutting systems are never adopted on the continent in steep mountainous country.

Of the selection systems, the pure selection system (by which I mean taking out single trees here and there) is out of the question; the chir occurs and reproduces naturally in groups and must be treated in groups. For this reason the selection-in-group system has one great advantage, in that we can free groups of regeneration wherever they may be found throughout the forest.

But there are numerous disadvantages. I cannot conceive how, in practice, the selection-in-group system will tend to regularize or lead up to a normal forest; also, as already suggested, this is not the best system for the light-demanding nature and silvicultural requirements of the pine; and, again, with scattered groups of regeneration, we are increasing the dangers and possibilities of damage from fire to an unnecessary extent. If the forest is liable to excessive grazing, the same objection applies. Taking everything into consideration, one is obliged to admit that the disadvantages outweigh the one solitary advantage.

To turn now to the systems of regeneration in periodic blocks, which are, broadly speaking and avoiding minor distinctions:

(*a*) The shelter-wood compartment system and
(*b*) The group system.

Both systems are characterized by concentration of regeneration in the first periodic block and thereby make a definite attempt to form regular age gradations, and lead to a normal forest. In both systems, for the same reason, efforts to limit the damage from fire and grazing can with advantage be concentrated on the first periodic block.

As compared with one another, each system is characterized by special advantages and special disadvantages. If we have an extensive area of mature forest, ripe for regeneration, the first system will give us the most magnificent results. Leave five or six of the best seed-bearers per acre, sufficient to give the necessary seed, and at the same time not sufficient to interfere in any way with the reproduction. Spare no trouble or money in keeping out fire and grazing and success will be assured.

This is an ideal condition, which we seldom find in our forests. Try and apply this system to an area of alternating mature and immature groups, and we shall fail, or at best only partially succeed. Even the finest seed-bearers do not produce sufficient seed to meet the requirements of their own zone, and also the zone of other groups of trees. It is true that chir seed will fly a fairly long distance, but it will not fly a long distance in sufficient quantities to insure successful natural regeneration. If we put it mathematically and say that the quantity of seed reaching the ground varies inversely as the cube of the distance from the parent tree (which is probably not overstating the case), it becomes at once evident.

In such areas the group system with a long regeneration period has the advantage. The overmature groups and groups with advance growth can be freed at once. The groups which are not yet quite mature, but which will probably be ready for regeneration before the end of the period, can be left for the present. Groups of quite young poles, say up to 3 feet girth, if any such groups there are, must be left as part of the future crop. To cut out such groups, with the certainty of having to sow them up artificially, would be an extravagant sacrifice to the ideal of absolute uniformity.

This suggests the great advantage of the group system. Except in conditions most favorable to the uniform system, the greater elasticity of the group system will materially affect the amount of sacrifice involved, albeit, it must be confessed, at the expense of the even age of the future crop.

But in practice, in working a big block of forest of say 10,000 acres, when probably 2,500 acres will be in the first periodic block, it is most probable that there will be areas more suited to the uniform method and other areas more suited to the group method. We do not require 1,000 acres of uniform mature forest to start the uniform method; 100 or even 50 acres is sufficient to give us excellent results. In the well-known Forbach 'revier,' in the Black forest, I remember that no particular system of regeneration was laid down; the forest officer marked in selection, group, or even shelter-wood, if he considered it best. This seems to me, with some modifications, to contain the germ of the ideal system for our irregular woods.

Let the working-plan officer lay out the various felling series and select the areas for regeneration; let him fix the annual yield to be cut; let him, if he wishes, prepare detailed maps of the areas for regeneration and suggest where group or uniform fellings are indicated; let him even mark the first two or three years' fellings, to give an indication of how he thinks they should be done, but otherwise give the divisional forest officer a free hand.

This is, to my mind, the ideal solution. The question arises: Can we, with our present staff, and with the admitted fact that imperial officers are seldom available for marking work, carry it out? I would humbly suggest that if a more intensive form of management demands more staff we should ask for it. If we fail to get it, it is our misfortune, but scarcely our fault, and we must do the best we can.

So much for the first periodic block; a word must be said about the remainder of the forest.

I have indicated above that it is not sufficient to get regeneration where we want it; in order to get a regular series of age gradations, we should try and stop it from coming up where we do not want it. Once before I suggested a remedy for this—fire. In precipitous areas, or where soil erosion is paramount, in areas with heavy grass growth where even annual fires are destructive, in areas where for some reason a selection system has been adopted, this suggestion could not be carried out; but in other areas, of gentle slope and vigorous growth, with heavy grazing and no grass to speak of, where surrounding villages take a heavy toll of the dry fallen needles, and most especially where (as in parts of the Punjab) complete fire protection is precarious and unsuccessful, I think the suggestion is worth consideration.

In any large area of forest the mature areas ready for regeneration will probably be scattered about in various parts. By a judicious division into several felling series, and with a corresponding number of areas to be put under regeneration, it will usually be possible to utilize these mature areas to the best advantage. This would tend to minimize the inevitable sacrifice.

Since writing the above note I have had the opportunity of studying an interesting report by Mr. M. R. K. Jerram, of the Punjab, on the application of the group method to Himalayan coniferous forests. I am glad to see that many of his arguments and conclusions coincide with what I have tried to show.

He declaims against:

'Impracticability of making gaps of fixed dimensions and a fixed distance apart and increasing them by a fixed area.'

And again:

'Neglect of the silvicultural requirements of the crop, owing to fixed intensity of fellings.'

'Stem check is likely to act in opposition to silvicultural requirements.'

'The markings should be done * * * on purely silvicultural principles.'

Silviculture, in short, is his guiding star, and anything which cramps or hinders the applicability of silvicultural principles is banned. Only I have gone a short step further and argued for still greater freedom. Mr. Jerram also quotes the Forbach forests:

'The management of silviculture * * * may * * * and, so far as one can see, do work well,' but he thinks that the method would be impossible to apply to India. As carried out in Forbach, I agree; but toned down and modified (almost beyond recognition), as I have suggested, I think it would not be so impossible.

But the main idea which runs through this report is, if I have understood him correctly, a plea for freedom of action. 'In the Punjab * * * an attempt has been made to make the system almost mechanical,' and 'Personally I do not think it can ever work satisfactorily.' 'Give us,' he said in effect, 'absolute freedom to apply silvicultural principles,' and with this I most cordially agree."

One of the main objections to the application of the shelter-wood system in India has been the unusual fire risk from large areas of even-aged young growth which resulted from the use of this system. Mr. Smythies perhaps could have emphasized this more.

In a recent article Mr. Gallaher takes the ground that with the chir pine reproduction is usually easy, and that an intensive shelter-wood system should be applied. He states:

> "Chir is customarily treated under the shelter-wood system.[1] The first working plans proposed the removal of the stand in two fellings, but this proved unsatisfactory in many cases, and it has been found necessary to adopt more intensive methods. Later rules prescribe a heavy preparatory or seed cutting to remove about two-thirds of the stand, and a series of after-cuttings at intervals of about four years. All small trees, as well as deteriorating and unhealthy ones, are felled, and strong emphasis is laid on leaving the best seed-bearers, even though they may not be adding increment with such rapidity as other faster growing but less productive ones. Fifteen to twenty trees per acre are left after the seed felling, six to eight after the first removal felling, one to two after the second, and all are taken on the third. The last seed cutting within a periodic block is finished ten years before the end of the period, so that there may be no doubt about getting the whole regenerated within the allotted time. While fellings are customarily about four in number, the present tendency seems to be toward fewer cuttings, with more consideration for the needs of each individual patch rather than the whole compartment, and to lay stress on the fire danger, since fire, once started, is usually of such intensity as to destroy all living trees, large and small.
>
> The diameter limit is commonly fixed at 28 inches, with a rotation of the number of years needed to attain this size, as obtained from growth figures based on trees in the virgin forest. No yield tables for even-aged stands such as are produced by the shelter-wood system exist, and it may be necessary in the future to change both rotation and diameter limit. Hence the figures used are very conservative, due to the well-known fact that the culmination of the mean annual increment of the individual trees does not coincide with that of the stand, but is much later. It is admitted that if it were not for some loss in conversion a smaller exploitable diameter and a corresponding rotation would be more profitably employed, but 28 inches seems most satisfactory at present, all things considered.
>
> Occasionally the selection system is followed in treating chir. Such is the case on the Naina Tal forest, where much of the stock of merchantable timber had been removed before the inauguration of systematic management, necessitating a conservative cutting policy. The group or patch selection system is employed with the idea of improving the condition of the stand and bettering its yield. It is generally accepted,

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[1] Proceedings of The Society of American Foresters, October, 1913. The Himalayan Forests, by L. H. Gallaher.

> however, that chir is not adapted to this treatment, and it is employed only under such adverse conditions that a clear-cutting policy is impossible."

Corsica.—In Corsica the French Government commenced the cutting of Corsican pine (*Pinus laricio*) under the shelter-wood system. As the result of these cuttings excellent reproduction was secured, but because it was impossible to protect these young even-aged coniferous stands from fire, conflagrations wiped out the second crops secured by these early cuttings. Today the French are applying a patch system with thinnings. In other words, while trees may be cut out singly, more often groups of trees are removed; these groups are afterward thinned. In the words of a working-plans officer:

> "Since every pine is essentially a light-demanding species, in order to obtain natural regeneration, it is necessary to open up the soil quite freely, because a cover is not necessary for the seedlings. The stand which results from these pretended selection fellings does not necessarily have any similarity with the theoretical selection high forest; it is formed of large patches of timber of the same size, often of the same age, which follow each other irregularly. The size of the opening necessary to give all the light required for the development of the seedlings depends on the slope, on the total height of the stand, and on the condition of the soil. It cannot be fixed in advance, but the canopy may be freely interrupted, since the entrance of dangerous winds need not be feared."

But perhaps the most complete official description of the present method is given in article 8 of the Aitone working plan, dated November 30, 1907. Here the degree of regularity aimed at is well described:

> "The volume of trees 0.35 meter (13½ inches) and over in diameter, however realized, shall be counted against the yield. The forest agents shall be free to use whatever method seems satisfactory in estimating the felling. If it consists, however, of the chief or accidental yield, they will have to use the volume tables which were used in estimating the growing stock.
>
> The fellings will remove:
>
> (1) All the trees that are dead, defective, overmature, or completely decayed.
>
> (2) Trees measuring less than 0.35 meter (13½ inches) in diameter, and which are not required.
>
> (3) Small trees without any future.
>
> The agents should not lose sight of the fact that the selection method should not be considered as an empirical process in which one is limited to recruit the yield from dead trees, those overmature or of large size.
>
> * * * It includes the same operations as the method of regular high forest (seed fellings, secondary, final, cleanings, thinnings).

That which differentiates the two methods is that with the shelter-wood system the same kind of operations follow consecutively and are consequently massed in a district, * * * while that in the selection system these operations are scattered over the whole area of the forest in little spots. It therefore follows that the fellings protect one another, so to speak. Do not imagine, therefore, that the selection system confines itself to realizing the large timber alone. It is necessary within the perimeter of each felling area to practice all the essential cultural operations, to free the young growth, to thin the stands that are too thick, to cut out the trees which have no future, and never to lose sight of the fact that the really profitable growth is that which takes place in the trees destined to remain until the end of the rotation. At the same time one must avoid the tendency to regularize the stands by allowing any particular age class to dominate a large area just as one must avoid breaking the cover systematically to give it the aspect of a selection forest when managing a regular high forest of good growth."

Only one official reference to the size of the openings to be made has been found: "* * * In the stands of Corsica pine it will be best, whenever the density of the stand will permit it, to proceed by removing groups of trees so as to cut up the stand into openings of 0.07 to 0.10 of an acre, so that the seedlings of this species will receive the light they require."

France (*Provence*).—In the allepo pine forests near Marseille, France, which grow on dry limestone soil, the working plan advocates what amounts to a shelter-wood system. In practice the local officer is using a selection system, partly on account of the danger from fire and partly because of the danger from the desiccation of the soil, in case the parent trees are all removed or the reproduction should be burned. He feels that reforestation would be exceedingly difficult and expensive if these sites were exposed to the full effects of the climate. Inspector Bresson gave me the statement which follows, which was prepared for this article and is here published for the first time:

"The allepo pine is the only coniferous species of the calcareous regions of the Mediterranean Provence. Besides this species there is only the holm oak and the peduncolote oak, treated under coppice and furnishing nothing but fire-wood. In the Department of Bouches-du-Rhone the alep pine ordinarily forms almost pure stands or mixed with a small per cent of oak (0 to 15 per cent).

The forests of the alep pine occupy the lower mountains, where altitude ranges from sea-level to 2,600 feet. The soil formed from calcareous and cretaceous rock is generally on steep slopes, which is often rugged, with numerous rock benches and stone slides with but little vegetation. The climate is characterized by hot and dry summers. The average annual rainfall is 22 inches at Marseille to 27.22 at Areasque (in the center of the small mountainous forest situated to the northeast of Marseille). The average number of rainy days is 85, chiefly in autumn and spring. There has been an almost complete drought for two months—July and August.

The alep pine is admirably adapted to these conditions, which any other species would not be able to stand. It is essentially a light-demanding species, enduring drought; and, vigorous, with a very light foliage, it is easily regenerated by natural means. But while it stands heat and prolonged droughts, its growth suffers nevertheless, and its remarkable thrift when near water shows it can endure fresh soil. The young seedlings, if their roots are not well into the soil, suffer from drought, and are often burned by the sun in summer, which is especially hot and drying on certain rocky slopes where the open stand can't get regeneration even under old trees; on the other hand, the soil should not be let run wild and must be protected against the heat of the sun. Cuttings must be prudent (light).

The treatment as regular high forest (shelter-wood), with a rotation of 60 years and with the division of the forest in three 'affectations,' each to be regenerated in turn within 20 years, has been followed in a number of forests for 50 years. But the looked-for regularity has not been obtained on the arid and rocky soil which one finds on most of the area under management. Uniform stands have only been obtained on several areas *where the soil was deeper and richer,* which are the exception rather than the rule. In reality these areas (treated by the shelter-wood system) have always remained in a transition stage.

On the contrary, the selection system is adapted to the regional conditions. Forests of more than 740 acres are divided into 'series,' whose area ordinarily does not exceed this. Each series is divided into a certain number of 'coupons' (10 to 16 usually), which are cut over each year successively. (The area of each coupon usually varies from 12 to 50 acres.) The number of the 'coupons' fixes also the periodicity of cutting over the same point (10 to 16 years) * * * and at each cut one removes the trees which have attained exploitable size along with the badly shaped and overmature trees; one thins at the same time the trees where they are too thick and frees the promising seedlings. The yield is not fixed; the cut removes each time 15 to 20 per cent of the standing material. Seedlings ordinarily come in quickly where the stand has been opened; and if the neighboring trees shut off a portion of the sun's rays, when it is low on the horizon, the effect, because of the intensity of the light and the lightness of the cover, is not bad for the seedlings, but, on the contrary, preserves them against any dangers of excessive heat and drought.

The selection method gives in the end excellent results from the cultural viewpoint and is perfectly suited to the silvics of the alep pine, as well as to the soil and climatic conditions. It assures the conservation of the stand, something that is essential in our region, where the per cent of wooded areas is much too small (14.2 per cent). It yields trees (to be sure) without a very long stem—about 36 feet in height—which is sufficient, however, for very mediocre soil. Moreover, the length of the stem is of secondary importance, because when the alep pine comes to the sawmill it is cut into small box-boards for shipping crates. From the economic viewpoint, since the yield is not established, there is the objection of giving a very great latitude to the officer who does the marking. *But it must be remembered that because of frequent fires* * * * *it does not seem feasible to establish a precise working scheme which would have to be incessantly revised and whose provisions would be constantly reversed."*

Russia.—In accordance with a memorandum giving the gist of a series of conferences at the Fort Valley Experiment Station with Mr. Tkatchenko, a member of the forest special committee of Russia, he approved the statement that:

> In Northern Russia the selection system is used for Scotch pine, while in Eastern and Central Russia the strip system, followed by artificial regeneration, is applied to the same species. Economic conditions are the reason for this difference. * * * *On a good quality of locality* the stand (shelter-wood—compartment), together with cuttings at 15-year intervals, is used.

The weight of the evidence of European practice is thus strongly in favor of the selection system in Class 2 sites, where Mr. Clapp advocates the shelter-wood system. If one tours Europe, it is impressive to note that the shelter-wood system is only used successfully where the conditions for reproduction are *favorable* and where *regeneration is certain* within a reasonable period. European practice indicates the shelter-wood system for Class 1 sites, where Mr. Clapp advocates the group selection system. It is worth noting, too, that where reproduction does not come in readily in cases where the shelter-wood system has been tried the cuttings usually develop into a form of the selection system; to have the shelter-wood system successful, prompt, and easy, regeneration is an integral factor. Theoretically, the writer would advocate on Site 1, where reproduction is certain, shelter-wood cuttings with safety fire-seed trees always standing, singly or in groups, and each cutting separated by blocks of heavy timber, in order to reduce the fire risk; on Site 2, where reproduction is possible, selection cuttings, removing perhaps 20 to 40 per cent of the stand; such light cutting, to be true, would be impracticable under present market conditions without too great a sacrifice in price, but this part of my discussion is purely as a theorist; and on Site 3, where feasible, the removal of dead, diseased, and dying trees without primary reference to the presence or absence of reproduction—a light improvement cutting.

4. PAST PRACTICE IN THE FOREST SERVICE

From the practical standpoint, however, our problem must assume a different aspect. The Forest Service is bound to dispose as rapidly as possible of its overmature timber. This is of vital importance financially as well as silviculturally, and in order to secure this removal the lumbermen must have enough to justify logging operations. From the Service standpoint a lighter cut would enable a larger area to be cut over at the end of any given period. A heavy initial cut means that it will take longer to remove overmature timber which is now distant from the railroad. In this connection the problem of cutting cycles in selection cuttings has not, I believe, been considered with sufficient care. Broadly speaking, with a rotation of 160 years and the removal of 50 per cent of the timber in each cutting, the cycle of equal cuts would be over 80 years. Even if but one-fourth of the timber were removed, the cutting cycle would be, roughly speaking, every 40 years. In other words, if two-thirds of the timber is removed, the next cut is going to be deferred longer than we now assume; it will probably not wait the full cutting cycle, because there will still be overmature trees which *must* be removed even if our growing stock is dangerously reduced. On the whole, it would be better forestry today in our "selection" cuttings if less than an average of two-thirds of the stand were cut. We shall undoubtedly come to this view of the situation. Therefore, if timber-sale contracts guarantee for long-term sales that at least two-thirds of the volume will be marked for cutting, it is unfortunate, because with better market conditions the company could afford to cut less per acre, and yet we shall have our hands tied by a definite contract. Before considering in detail the present practical solution of the problem, let us review what the official marking instructions have been during the past five years. These are of interest, because they drive home the fact that today—and rightly so—in our irregular virgin pine stands we are marking a heavy improvement cutting rather than executing the first cutting of some formal system.

The instructions for marking western yellow pine in District 3, dated November 3, 1908, were as follows:

> Yellow-pine stands are naturally open, and on much of the land isolated in this type the ground is now but partly and insufficiently stocked with young timber. In many cases the forest maintains itself as against chaparral with difficulty, and reproduction depends largely upon the protection against evaporation. This makes a selection system of marking obligatory. A conservative policy is especially advisable, since the areas of forest are constantly becoming more accessible to market, and there is every indication of a strong future demand at greatly increased prices.
>
> All marking, then, should be by a conservative selection system. But the exact form of cutting must be decided according to the nature of the stand. Two conditions ordinarily present themselves:

> First, where there are young trees present and a second cut can be obtained in about forty years. Sales should rarely be made except where this is possible. In such cases at least one-third of the trees at present large enough to be merchantable must be left for a future cutting. This means that at least 1,500 or 2,000 feet should be left to the acre, and in heavy stands more, up to one-third of the total stand. No sales should be made in stands so open that 1,500 feet cannot be left and the logging done at a profit. Leave all black-jacks unless plainly undesirable from serious unsoundness or overcrowding, or so misshapen that they will not develop into valuable timber trees. In general, leave all thrifty trees which will plainly be much more valuable at the time of another cutting.
>
> Second, where the stand is composed wholly of mature or overmature timber or with only very scattering black-jacks or healthy young yellow pines. In such cases it will be necessary to start a new crop from seed, and consequently in any cutting enough seed trees must be left to seed up the area amply. Before marking any tree for removal, therefore, be sure that it is not needed for seed, for the best trees for producing seed, irrespective of size, must be left. Young, thrifty, yellow pines or large, thrifty black-jacks with full crowns make the best seed trees. "Enough seed trees" usually means from two to five to the acre, the number varying with the seed-bearing capacity of the trees. If young trees that are just beginning to bear cones are left, at least five are needed to the acre. From two to four seed trees are enough if they are old and have large, spreading crowns and are wind-firm. The trees left should, wherever possible, be distributed in small groups. This makes them more secure against windfall and conforms to the grouping tendency of the western yellow pine. Leave enough seed trees, even where the seedling growth is good, in order to secure reseeding in case of fire. This method is, at best, unreliable and should be used only in extreme cases.
>
> These two conditions grade into each other, and the exact method of marking to be used will require nice adjustment on the part of the Forest officer. Arbitrary rules are useless. It is well, however, never to make an opening of more than one-quarter of an acre in the forest, nor to enlarge a natural opening of a greater size, even if the trees left are mature and partially unsound, unless good reproduction is already well established.

It is evident that even in 1908 the idea was to mark conservatively by the "selection" system, and yet (sic) up to two-thirds the timber was to be cut and two to five seed trees to the acre were considered enough. Natural openings were not to be enlarged and officers were instructed "never * * * make an opening of more than one-quarter of an acre * * *, even if the trees left are mature and partially unsound * * *." Such advice as this was manifestly unwise and ultra conservative.

In 1910-1911 the gist of the marking instructions were embodied in Bulletin 101. They were as follows:

Ordinarily all mature and overmature western yellow pine should be marked, except when required for seed or protection, since they have practically stopped growing. Similarly all trees which show such defects as punk knots, spike tops, bad crooks, low forks, and injurious fire scars should be marked for cutting. Even an approximate diameter limit should be flexible. Young, thrifty, rapidly growing trees should not be marked, even if larger than the stated diameter. Defective trees of any usable size should be marked unless there are technical or practical objections.

At least one-third of the stand should be left to reseed the area, provide a second cut, and protect the soil. No iron-clad rule, however, can be made that will apply to all conditions; consequently the amount left standing should be varied according to local requirements. The economic need of an early second crop should have weight.

Where the danger from windfall is great but few trees should be marked for cutting. This rule would also apply where a dense forest cover is needed for the protection of a watershed or to prevent erosion. The probable harm from too heavy marking on all slopes and in exposed situations must be carefully considered. Each tree left should have its crown free enough for vigorous growth. If usable, trees which have been badly grouped and have only small, sickly crowns should be marked unless needed to preserve proper soil conditions.

Where there are not enough young trees to form a good stand in the future seed trees must be left. These should be thrifty and capable of bearing large quantities of seed at once. Occasionally it will be necessary to retain seed trees too misshapen or defective to be merchantable, but as a rule young trees which will yield good lumber in the future should be chosen. Where western yellow pine is growing in mixture all seed trees should be of the more valuable species, but poorer species are better than none. In situations where logging is difficult the practicability of logging individual trees should be considered.

Fewer seed trees should be left where partial reproduction is already established than where there are no seedlings, yet if there is danger that fire will run over the area enough trees should be left to seed the ground fully, whether reproduction is present or not. Large openings should not be made or small openings enlarged where the future forest will suffer. Seed trees should always be left on the edge of openings, such as old burns, on the side from which the prevailing winds blow. On ridges and along the edges of parks it is usually advisable to mark very conservatively.

It often happens that some dry-topped and diseased trees which can and should be removed are overlooked in the original marking. It may also be advisable to reserve seed trees that were originally marked. Necessary changes in the first markings should be made before the sawyers have moved away. It is only by a careful remarking that undesirable trees can be completely eliminated and necessary seed trees retained.

In marking timber a simple rule to remember is: Mark most yellow pine and leave all healthy black-jack except when in need of thinning. This rule should be varied according to the age and condition of the stand marked. If the timber is mature, with no reproduction, it may be necessary to retain trees that are fully mature, and approximately one-third of the volume may have to be left standing, even at some risk of windfall and decline in vigor. In a mature stand with good reproduction the marking may be heavier, but sufficient trees should be left to provide for reproduction in case of fire. The marking should aim to open up the reproduction and enable each group to enlarge. It should also tend to improve the stand by removing dry-topped or otherwise deteriorating trees. In a pole stand of black-jack thinning can often be made to advantage, but these should never be heavy and should aim to preserve a close canopy. Trees which should be removed are those that are deteriorating and which may be eventually suppressed.

In marking any sale area innumerable variations will be encountered, and no uniform system should be adopted for the entire stand. On the border of the woodland type the marking should be merely an improvement cutting, and if the stand is less than 2,000 feet per acre no cutting whatever should be allowed except the occasional removal of dying trees, and this only if practicable from a lumberman's standpoint. On the borders of parks and where windfall is likely, or where it is desirable to preserve forest conditions, marking should be particularly conservative. On dry south slopes and on ridge crests but a few trees should be removed. Ordinarily in western yellow pine an approximate diameter limit of 20 inches should be stated, though not followed literally in the marking, as already explained. Wherever practicable advantage should be taken of good seed years to increase the cut or to direct the marking where the local seed crop is best. The scenic value of timber along roads must be carefully weighed.

The latest official instructions were embodied in a circular dated November 30, 1912.

The general system followed was that of shelterwood-selection cutting, the aim being to secure regeneration of the stand within the forty or fifty years which must elapse before a second cut can be profitably made.

* * *

The gist of these principles is as follows:

Since western yellow-pine stands vary so greatly, there can be no hard-and-fast rules as to the amount of timber to be left after the first cutting, and every area marked for cutting should be made the subject of a careful study from the point of view of both the silviculturist and the lumberman. The first object should be to leave enough trees to insure protection and seed, with the smallest loss of merchantable timber; for it must be borne in mind that if mature trees are left many of them will be lost through windfall or decay before the second cutting can be made.

A matter of first importance is the distribution of the trees left after cutting. The aim should be to leave trees where they are needed, and not simply to leave a certain number of seed trees per acre. Where there are large natural openings a number of seed-bearing trees should be left on the borders, especially on windward side, but where there are good stands of poles beyond danger from fire no mature trees should be left. Of course, where there is still a fire risk a sufficient number of old trees should remain to insure reproduction in case of a burn.

The principles governing the marking of trees of the intermediate age class in yellow-pine stand do not seem to be clearly or uniformly understood in all cases by the men in charge of sales. Trees of this age class should uniformly be reserved as far as possible. This will apply the shelter-wood system more effectively, both as to the securing of reproduction after cutting and as to insuring a second cut within a reasonable period when the shelter-wood should be removed and the new growth freed. Both points are essential to effective results under this system. The general leaving of trees of the intermediate age class will distinctly better our opportunities for success in both of these respects. Furthermore, from the broad standpoint of the increase in the value of trees of this age class, both through further growth and increased stumpage prices, it is distinctly desirable to leave as much of this timber as possible.

The rule should be to leave trees of the intermediate age class (construing the term liberally) unless some strong reason exists for their removal. The presumption of the marker should be to leave them, not to cut them. The reasons which would justify their cutting are: (1) Giving the operator the proportion of the standing timber on the sale area which is guaranteed by the contract. This should, however, be determined by frequent, accurate checks, not by guesswork. (2) Freeing the crowns of black-jack or well-established young growth underneath trees of this age class. Where the new stand has already been secured, the leaving of such trees is obviously unnecessary for shelter-wood, and any gain in their growth will doubtless be more than offset by the increment of the young trees freed by the cutting of the intermediate trees above them. (3) Serious defects which indicate early death. (4) Serious exposure to wind-throw; not much weight should be given to this factor. It should apply only to individual cases where the form of the trees or their peculiar location makes them particularly susceptible to wind-throw.

There is a tendency to construe the rules regarding defects as requiring the marking of young and middle-aged timber too strictly. While the removal of all defective trees is theoretically very desirable, in semi-arid regions, where at the best it will be extremely difficult to leave a sufficient stand to insure reproduction, such rules should be clearly subordinated to the requirements of the shelter-wood system for as even a distribution of cover on cut-over areas as possible. The cutting of trees having minor defects should not be permitted to break up or even to any extent reduce the shelter-wood. Such defects include fire scars, cat faces, small lightning scars, crooked or distorted crowns, thin crowns in black-jacks or trees of the intermediate age class, and mistletoe in moderate quantities. Where the reservation of shelter-wood is so essential to any reproduction, these should be classed as *minor* defects not ordinarily indicating that the trees should be cut. The general rule should be that unless the defects are sufficiently serious to indicate the death of the trees within ten or fifteen years they should not be cut if their retention from the standpoint of age, etc., is desirable. This rule should be applied to trees infected with mistletoe. While I realize fully the advantages of ridding the stands of this disease as far as possible, I do not feel that the cutting of mistletoe-infected trees should be permitted to break up the shelter-wood necessary on a sale area. Unless, therefore, a tree is dying from mistletoe or is so completely infected that its early death is probable, it should be left, if that is desirable from other standpoints.

As to the details of executing our officially established rules, the greatest lack of success has been because those marking were too rigid and iron-clad in their interpretation of instructions. Men have evidently felt that at least one-third the stand should be left on every acre, or even on every forty, whereas the proper silvical treatment of the stand may demand a variation every few yards, depending on the condition of the overwood, the presence or absence of reproduction, the topography, danger of windfall, practical logging requirements, and occasionally the quality of the soil.

The following examples are from markings executed under the writer's direction in November, 1913, on the Carson Forest. They illustrate the need for a wider variation in the amount retained per acre. The methods were, however, narrowed somewhat by the need, under the proposed contract, of marking *on an average* at least two-thirds of the merchantable stand. The tables follow:

No.	Stand.	Percentage.			
		To be cut.		To be left uncut.	
		Feet B. M.	Per cent.	Feet B. M.	Per cent.
1	Overmature yellow pine and black-jack on edge of park	26,010	43	35,050	57
2	Mature yellow pine, Douglas fir, and blue spruce, with thrifty black-jack on southerly and easterly hillside	16,980	61	10,980	39
3	Overmature yellow-pine tie timber, with some Douglas fir and very little black-jack	11,140	65	5,860	35
4	Mature and heavy stand of yellow pine, with but little black-jack on flat bordering forest settlement claim	36,140	66	18,470	34
5	Overmature yellow pine and black-jack, very good pine reproduction	48,390	85	8,360	15
6	Composite type; timber mature, with good white-fir reproduction and a little Douglas fir	27,190	88½	2,520	11½
	Total average	166,450	66	81,240	33

No per-acre figures are given, since the plots marked may not be a fair average of the stand for the entire sale area; what the average is could only be determined by systematic valuation surveys, which would be expensive to run.

In some of our marking we should be able to modify the methods according to the presence or absence of an immediate seed year. Moreover, the presence or absence of sheep grazing can be made use of. With a good crop of seed, certain felling can be heavier, and sheep grazing can be regulated so as to work the seed into contact with the soil. But it must be remembered that usually one seed year cannot start satisfactory regeneration.

The so-called "border cuttings" have their silvicultural drawbacks; before they can be successfully applied there is also the need of more intensive market conditions. Moreover, any clear-cutting system, if not largely modified, will sacrifice the pole stands of "black-jack," which are so typical of western yellow pine in the Southwest. On the whole, under present conditions "border cuttings" are impracticable.

5. THE SOLUTION TODAY

To reach a decision as to how to cut, putting the present practical viewpoints first, we must assume the following: *Since we have mature and overmature western yellow pine which must be logged under practical conditions as rapidly as possible to avoid waste through decay, how can these stands be cut to their best silvical advantage, taking into consideration the ever-present fire menace on most western forests?*

The problem of fire is present on almost all western yellow-pine sites where there is grass and young growth. This is, of course, augmented by debris after sales unless this is completely or partially burned, which is not always feasible. Therefore, with present conditions, unless the fire risk is negligible, when reproduction is freed by any form of cutting, at least a few safety seed trees should ordinarily be left as an insurance measure, even on Site 1. Even one or two trees per acre would insure some reproduction, and if planting were finally necessary these trees would shelter the young stock. This is especially true at lower elevations on south slopes, where there is the additional risk of drying out the soil by clear cutting. Here on Site 2 we must go further and always retain a portion of the mature stand as an irregular selection forest. *We must consider the silvics of each acre rather than any per cent to be removed.*

How much must we cut? At present an average of two-thirds the stand is almost uniform; in many overmature stands with advance reproduction, much more (as high as 85 to 90 per cent) may be cut with benefit to the forest; elsewhere a two-thirds cut may be far too much. In thrifty pole stands of "black-jack" perhaps only 15 to 20 per cent can be removed. On general principles our cut should be less than it is at present, so that we can dispose of the mature timber the more rapidly through cutting over a larger acreage each year. It is felt 50 to 60 per cent of the stand would be a better *average* for a large sale area as contrasted to the present 66 to 75 per cent. Yet no average should be standard. Overmaturity may mean a much heavier cut, and large areas of "black-jack" pole stands alternating with mature groups of yellow pine may require an *average* of but 40 per cent for the cut. In Arizona and New Mexico the cutting is now generally believed to be somewhat too heavy; if to cut less means a higher cost to the purchaser, this must be allowed for in the stumpage appraisals. Moreover, in just the places the cutting should be light it often happens that the timber is unusually overmature and consequently demands immediate removal. Yet where the land being logged can be classified as chiefly valuable for agriculture under the act of June 11, 1906 (and where such a classification will not interfere with the objects which prompted the creation of the forest), the stand should be clear cut in the course of a regular sale, unless there are other qualifying reasons why this could not be done. *With these general measures to apply to all sites,* what then should be our methods of cutting today where we are growing saw-timber?

1. *On areas where reproduction is certain and easy.*—(*a*) It is believed that on the favorable sites, where complete reproduction is present, the mature stand should be removed (say 90 per cent) except for fire seed trees. This would leave the young growth with a few seed trees for fire insurance. (*b*) On areas where the stocking was about half complete about 60 to 80 per cent of the overwood should be cut; after cutting, the forest would consist of groups of advance growth which had been freed from the overwood, especially on the perimeters of the groups, alternating with clumps of timber which had been *heavily thinned to promote reproduction.* At the next cutting, preferably within thirty to forty years at the latest, the method under (*a*) would be applied. The only difference would be in the regularity of young growth. (*c*) Where the regeneration has developed into pole stands "black-jack," with a few scattering small-sized clumps or individuals which are fully mature, these ripe trees should be clear cut and no safety fire trees need be retained. The "black-jack" should be lightly thinned.

2. *Where reproduction may be possible, but the conditions are uncertain and unfavorable.*—Here the stands cut less in board feet per acre

than under 1, and to justify logging a higher per cent of the stand has been cut than is usually best, but withal enough must be cut to allow immediate profitable lumbering. (*a*) At least an average of 50 per cent must be cut even where there is no reproduction; this cutting should merely remove the overmature and enough of the mature trees to make up the cut. This cutting should not be by groups of trees unless every tree in the group is very overmature, and ordinary silvicultural common sense should be followed in selecting the trees to remain. (*b*) "Black-jack" stands should be merely thinned very lightly, and openings should not be enlarged *unless* the trees that would otherwise be retained are diseased or very overmature. A stag-headed tree with sickly foliage is better cut than left, even if an opening is enlarged. The retention of very tall trees (trees with 4½ to 5 16-foot logs) is rarely necessary. *This type of forest, with increased fire danger, owing to more serious droughts, should be cut so that the parent stand will always be present and so that the future stand will be uneven-aged.* This will mean some sacrifice and has its inconvenience, but seems obligatory. The return cut should, if possible, be every 20 to 40 years, and a far lighter cut, it is hoped, may be made then. If the cut is every 25 years, *after this first cutting removes the bulk of the mature timber,* the normal amount removed can be about 20 to 30 per cent of the stand, depending on the rate of growth, the rotation, and logging conditions. Yet this may not be possible, since, unless the intensiveness of logging enables a far smaller cut per acre than at present, it may be necessary to log more heavily where reproduction has come in, and where there is none only make a very light improvement cutting. The main difference between 1 and 2 is that in 2 the *parent stand will always be present* and the young growth quite irregular. In Site 1 no attempt need be made to retain the parent stand except for the few safety fire trees which may be necessary as fire insurance.

3. *Where the conditions are unfavorable to tree growth.*—Here a light improvement cutting should be made (this will often be practicable when cut in connection with the lumbering of more desirable timber) and the diseased, dying, and dead merchantable trees cut. Even if there should by any chance be reproduction, only a light cutting (say 15 to 30 per cent) should be made. No stand should ever under any circumstances be clean cut, even if immediate planting were practicable. *It will be noted that in these directions no systems have been named; a simple silvicultural procedure has been promulgated dependent on the reproduction and maturity of the timber;* nor should this procedure ordinarily be hampered by the mathematics of management limitations.

In all cases the practical requirements of every-day logging must be considered before marking. It is obviously only reasonable to clear cut on steam skidder trails where this form of logging is allowed. The "protection" or "scenic" forest, on the other hand, must only be cut lightly.

When deciding which trees must be cut, it would be short-sighted if we did not consider the cost and feasibility of marketing the material grown as well as the kind of forest product demanded. For example, where it was only possible to drive ties or short mine props through a box canyon it would not ordinarily be advisable to grow timber of large dimensions. In this case perhaps a valuable supply of virgin timber would justify the lumbering of the saw-timber when the land was logged for the first time; a large output would pay for the railroad. But in subsequent cuts the amount in quality and quantity would be so reduced that the lumberman could not afford to lay steel. He must drive the box canyon and rest content with the marketing of ties and props. The retention of saw-timber seed trees at the time of the first cut, unless for some special silvical reason, would ordinarily be unwarranted. This would mean a departure from the cut given in the table below.

6. TABULAR SUMMARY

These principles are put concisely in the following table:

Approximate elevation.	Character of stand.	Per cent of area covered by reproduction.	Approximate per cent of merchantable stand to be removed, and nature of cutting.	Nature of next cutting (interval will depend on market and on reproduction in sites 1 and 2).
Site 1.—Reproduction certain.				
8-9,000	Thrifty "black-jack."	5	0 to 10 in light thinning.	A thinning.
8-9,000	Thrifty "black-jack," with few mature yellow pine.	5	30 to 40 by removal of mature timber and thin "black-jack."	do.
8-9,000	Mature yellow pine.	70	Cut 80 to 90 of mature timber.	A thinning and removal of fire seed trees.
8-9,000	......do..........	40	Cut 65 to 75 of mature timber.	Cut 80 to 95 per cent of mature timber.
8,500	.....do..........	20	......do..........	do.

Approximate elevation.	Character of stand.	Per cent of area covered by reproduction.	Approximate per cent of merchantable stand to be removed, and nature of cutting.	Nature of next cutting (interval will depend on market and on reproduction in sites 1 and 2).
Site 2.—Reproduction possible, but irregular.				
7,000	Mature and overmature yellow pine.	0	40 to 60 by removal of overmature and few mature trees.	A lighter cut, selecting oldest trees at regular intervals.
7,000	......do..........	5	......do..........	do.
7,000	......do..........	40	......do..........	do.
7,000	"Black-jack."...	0	0 to 10 in light thinning.	A thinning.
7,000	"Black-jack" and half yellow pine.	0	40 to 60 by removal of portion yellow pine and thin "black-jack."	A thinning, selection of trees at regular intervals.
7,500	A typical selection forest.	15	40 to 60 by removal of oldest of trees.	A selection, cutting lighter in per cent removed at regular intervals.
Site 3.—Reproduction difficult and uncertain.				
10,000	On south slope scattering trees on exposed points.	5	Remove dead, diseased, or dying trees by cutting 5 to 20 per cent.	Improvement cuttings at regular intervals if possible.
6,600	Overmature yellow pine.	0	Remove dead, diseased, and dying trees by cutting 5 to 20 per cent.	do.
6,600	......do..........	20	......do..........	do.
6,600	......do..........	50	Remove dead, diseased, and dying trees by cutting 5 to 20 per cent; perhaps cut to 15 or 30 per cent.	do.

In the foregoing table it will be noted that where the reproduction is certain no effort is made to always retain a portion of the present stand, and the intensity of cutting is directly influenced by reproduction. At intermediate[2] elevations, where the reproduction is possible but irregular, the aim is to always retain some of the parent stand with the direct idea of leaving an irregular forest.

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[2] At this elevation, where a recent cutting on the Coconino entirely uncovered the reproduction, the future stand suffered very severely. Of course, this is not conclusive. Clapp's chief stumbling-block seems to have been his picture of the shelter-wood system for Site 2, where he dreamed of a sheltering stand for the tender seedlings.

At the extremes of the yellow-pine type the removal is only a very light improvement cutting, with perhaps a slight increase in intensity, with better regeneration on the ground. This is my solution; it can usually be applied. I challenge Clapp to apply to Arizona and New Mexico the "systems" which he advocates; if it cannot be applied in the Southwest it is of doubtful application elsewhere.

The final solution can only be secured after years of practice, and even then may have to be modified with changing market conditions and different methods of manufacture. So long as overmature trees are cut and the merchantable timber fully utilized, with due regard to the necessity of uncovering existing advance growth and the protection of the forest at exposed points, no apology need be made in the future for the solution of today—an expedient admittedly based on today's market conditions.

AN AFFORESTATION SCHEME FOR SOUTHERN CALIFORNIA

BY JOHN C. SMOCK

Contributed

Southern California may be divided into three fairly well-defined topographic divisions: the intramountain or Mohave Desert region in large part; the mountain, consisting of the Sierra Madre, San Bernardino, and San Jacinto ranges, and the coastal plain—that part of the State lying south and southwest of these ranges and stretching westward to the ocean. The western limit of this coastal plain may be put at Point Concepcion on the Pacific Ocean. It extends east and southeast from this point or limit, as here designated, 200 miles and to the international boundary. Its breadth varies from little more than 2 or 3 miles at the west to 50 miles near San Bernardino, Riverside, and Newport. The area of this triangular coastal plain is about 6,500 square miles, or a little more than 4,000,000 acres. It is not, however, strictly defined as a plain, but has within its limits high hills and even mountain ranges, although altogether subordinate in height to the great barrier ranges on the east and northeast. Between these coastal-plain ranges of hills lie smooth and gently contoured valleys which still further diversify the surface. The natural fertility of the soil in many of these valleys and lesser plains, and its adaptability to horticulture and to citrous-fruit crops particularly; the climate, mild and salubrious; the abundance of water in the great ranges of mountains on the north, available for irrigation in all parts of this coastal plain, all combine to make this natural division of the State a highly favored region whose attractive features are widely known. And it has acquired a world-wide reputation for its wealth of products of the soil, and the land values per acre for uses in agriculture and horticulture are as high as anywhere in the United States. The great aggregate value of the products of the ranches and the fruit orchards is evidence of the large amount of capital invested in lands devoted to horticulture and agriculture. To the land capitalization there must be added the amount of capital invested in the irrigation plants and in the establishments for the economic handling and marketing of the crops.

The climatic advantages of southern California are a great asset of capital, and a consideration of some of the factors of the climate makes a subject of great importance to the cultivator of the soil and the fruit-grower as well as to the general public and to the student of climatology. And the recognition of its importance is seen in the large use of protective measures against damage from frosts in the extensive citrous-fruit orchards of this coastal plain. Shelter belts of trees are planted in many places, and smudge fires are in general use throughout the whole district for protection against such injury from severe frost. In spite of these more or less costly methods of protection, the losses through freezing of the fruit and of the tender shoots and tree buds are in some years large, amounting, as in the season of 1912-1913, to nearly complete failure of the fruit crop.

It has occurred to the writer that while protective measures have been employed so generally, and in many years so effectively, it were well to look further and see if there were not some other agencies which might be considered as worthy of attention and which might be suggested as aids to the measures now in use. The indirect amelioration of the climate by alteration of the vegetal cover and a consequent diversification of the surface is here suggested. This amelioration of climate may consist in the reduction of the wide daily range of temperature, and in the slightly lower maxima and correspondingly higher minima in both the warmer and in the colder or wet seasons. The wide daily range may be diminished by the increase in the amount of moisture in the air stratum lying immediately upon the surface of the ground, through the upward passage of moisture from the thick mass of vegetal material in the form of luxuriant plant growth or humus resulting from the decay of plant matter, and the general effect of an increase in the air moisture would be to make the temperature more equable.

At present a large part of this coastal plain is nearly destitute of any vegetal covering sufficient to serve as a screen against excessive heating through long-continued periods of sunshine and to prevent the rapid loss of moisture by evaporation and the excessive radiation of heat during clear nights with their cloudless sky. The severe frosts, which do so great damage to the citrus-fruit orchards, as well as to all the more tender vegetable crops, are due in great part to the rapid rate of night radiation of heat, and exceptionally low minimal temperatures of the early morning hours show the great influence of this radiation of heat during the long nights of the colder months of the year. The barren "washes," the exposed soil surface of the cultivated land, and, more than all, the large aggregate area of bare hills and low mountain ranges, with their thin chaparral cover, work together in intensifying the action of the heat-radiating factor of climate. The proper consideration of this element in the climatic conditions of southern California is of the highest significance in any development of a well-ordered system of agriculture and of agricultural methods suited to the country. How far the natural semi-aridity of the coastal plain may be due to some changes in the extent of the forest since the latest of the recent geological periods is altogether beyond the limits of this paper. Probably the desiccation of the country has brought about the passing of the forest cover and the baring of the surface more and more to the drying-up agencies of insolation, radiation, and evaporation. The drying up of streams and other natural phenomena incidental to a regional desiccation consequent upon the destruction of the forest in some countries of Asia and also in Europe have been studied with great care by writers on historical geography and by students in the science of forestry. The results of careful observations of these phenomena appear to show that the too great deforestation of any given district of country is attended with disastrous changes in the equability of the streamflow and also in an increased radiation of heat, accompanied with wider range of temperature of the air and climatic extremes more or less affecting the vegetal growth.

It is reasonable to hold the converse of this proposition as also true, and to look upon afforestation as a remedial measure in the problem of a possible amelioration of climate in a region lacking the proper distribution of forest; but it is not possible, in advance of any reforestation work, to determine the extent of such amelioration in climate which might result from a change in the forest cover of any given area or district of country. We cannot state in degrees of temperature the tendency toward equability, nor the percentage increase in the hygroscopicity of the air, nor the additional precipitated water of the rain or snow which a forest cover might tend to produce in any country, however situated; but, reasoning from what has been observed in some of the slight changes in temperature and a lessening of extremes of cold and heat, and in the increase in the precipitation, due apparently to the work of afforestation, it would seem to be within the limits of possibility that by the rehabilitation of this country with a forest covering the conditions might be so altered that the daily range of temperature might be lessened and the distribution of rainfall be such as to insure a more uniform amount of moisture in the soil as well as a larger streamflow in all the seasons of the year.

The possible extent of afforestation in this coastal-plain division of California is limited to washes, in part, and to the hills and lower mountainous districts, which are so steep in slope and gashed by erosion that they are suited to profitable cultivation of soil. Large areas are so situated that they cannot be irrigated either through lack of water supply or because of their steep slopes. The study of the topographic features—the physiography—is apparently the key to the situation. The valleys and the plain lands are too valuable for agriculture and horticulture to be given to timber raising. The topographic maps of the U. S. Geological Survey give a correct expression of the surface configuration, and from a careful study of them it is possible to determine approximately the location and the extent of the several areas which by reason of their uneven surface are unsuited to the uses of the cultivation of the soil and the citrus-fruit grower.

In this paper the results of a careful study of the U. S. Geological Survey maps are given.

Beginning at the west in our survey in detail of this coastal-plain division of the State, the border plain, lying at the foot of the Santa Ynes Mountain from Point Concepcion eastward to Santa Barbara, is nearly all under cultivation. The Santa Ynes Reservation is on the range of mountains on the north. East of Santa Barbara the hills near the ocean are too rough for cultivation in farms and they should be given to forest culture. In Ventura County there are several fertile valleys shut in on the south by the Sulphur Mountain and South Mountain ranges, barriers on the ocean side, rising to the heights of 2,200 feet and 2,600 feet respectively. And these mountains, having an aggregate area of nearly 200 square miles, should be devoted to forest. These valleys and the Ventura and Oxnard plains are all rich ranch lands. The afforestation of the mountains in this part of Ventura County would tend to benefit the beautiful Ojai, Simi, and Santa Paula valleys. Going eastward, in Ventura County and in Los Angeles County, the agricultural land is a broader belt, including the San Fernando Valley and other smaller valleys and the plain which stretches from the San Gabriel Mountains and the Santa Barbara Forest Reserve to the sea on the southwest. Rising above the ranch and orchard lands there are at the west the Simi Hills, 1,000 to 2,400 feet in height, and near the ocean the Santa Monica range of hills, whose higher points are 1,800 to 2,600 feet in height. Further back from the ocean Verdugo Mountain and the San Rafael Hills shut in on the south the beautiful La Canada Valley. The San Rafael Hills rise in one point to 1,800 feet; the Verdugo Mountain in a single knob is 3,100 feet high. The total area of these hilly lands in the eastern part of Ventura County and in the northern central part of Los Angeles County is about 440 square miles, nearly all of which is by its rough and uneven surface better suited to forest than to agricultural use. South of Los Angeles are the hills of Paso del Tijero and the San Pedro Hills, so situated in the plain that they might be put in forest to the advantage of the lower country about them. The maximum elevation of the San Pedro Hills is 1,352 feet.

East of Los Angeles the plain broadens and there are several ranges of hills diversifying its surface. One of these ranges has an eastward trend from the city to the Rio Honde, and its highest point is about 800 feet above the ocean level. Further east are the Puente Hills, covering an area of 37 square miles and 1,476 feet in height. To the north of west of Pomona are the San Jose Hills, 24 square miles in area and 1,380 feet high. The irregular and steep slopes of these hills forbid profitable cultivation in citrus-fruit orchards, and here again the hills in forest would no doubt serve a valuable purpose in various ways to the adjacent valley lands.

In Orange County, and extending into the southern border of San Bernardino County and the western part of Riverside County, are the highlands of Santa Ana del Ohino, up to 1,400 feet, maximum elevation; the hills north of Anaheim, 460 to 1,670 feet high, and the hills east of Orange, having in the aggregate an area of a little more than 100 square miles, which if they were in forest would diversify the nature of the surface and tend to promote equability of climate. At the border of the ocean, in Riverside and Orange counties, the San Joaquin Hills cover an area of nearly 100 square miles and are 1,185 to 1,500 feet in height.

In Riverside County there are the Santa Ana Mountains, the Trabuco Canyon Forest, and the Mission Viejo Hills; in all about 275 square miles of rough hills and having maximum heights of 1,000 to 1,645 feet. Nearer to Riverside there are the Turupa Mountains and the Box Springs Mountains. In the same country, to the south, the Lake View Mountains rise to heights of 1,500 to 2,629 feet; the hills around Elsinore Lake, 1,500 to 3,033 feet; in all an area of 270 square miles of rough land which should be in forest. In San Bernardino County there are the Grafton Hills, 2,250 to 3,540 feet in height, and the hills east of the Yucaipa Valley, 2,000 to 3,750 feet, suited to forest and not to agriculture.

The afforestation of these hills in Orange, Riverside, and San Bernardino counties would make the forest area about one-half of the coastal-plain division comprised within their limits, and this proportion of forest to agricultural lands would not be excessively large in this semi-arid country.

In San Diego County there are many smaller valleys in the interior and within 20 to 30 miles of the ocean, and in what may be considered as the coastal-plain division of this southern California. There are also the larger El Cajon, Otay, Lawton, Temecula, San Marcos, and the Escondido valleys, and the more immediate border land on the coast, including the country about San Diego, which are by nature agricultural lands. Their area is approximately 450 square miles. The remainder of the coastal-plain division in San Diego County, consisting of hills and low mountains up to 3,500 feet high, and the steep canyon slopes is at least 1,300 square miles in area, or about three times that of the lands suited to cultivation of the soil and other cultural uses. It is altogether probable that in the further settlement of these interior valleys and the development of the shore border lands incident to the rapid growth of San Diego and its suburban population, this comparatively large percentage of forest might be reduced considerably without disturbance of a proper proportional area of forest to cultivated farm land.

The total area of lands suited to agriculture and needed for cultural use in cities and towns in what has been designated in this paper as the coastal-plain division of southern California amounts to about 3,000 square miles, leaving 3,500 squares, or 2,240,000 acres, of land not suited to agriculture. At present these lands lying outside of the domain of agriculture are practically unproductive of any revenue to the State or to their owners, and excepting for the water supply are nearly valueless. As sources of any considerable water supply, important in the irrigation of the lands under cultivation in the valleys and on this plain, they are not nearly so valuable as the higher mountains on the north and northeast. The conservation of the water supply in this part of the State, where the annual rainfall is only about 12 to 20 inches and where there is a high rate of evaporation, is limited to the scanty flow of small streams in the canyons and to the subterranean water development by boring artesian wells; but the treeless condition of nearly all of these hills and the general absence of any thick vegetal cover, such as would tend to reduce the evaporation from the surface and to equalize the flow of the small rivulets, make them of relatively small importance as gathering ground for any water supply other than that which is highly local in extent and unimportant to the country as a whole. The afforestation of these lands would tend to increase the growth of the underbrush, and the accumulation of woody material in the soil would provide a repository for the rain-water, and thereby retain moisture in the surface stratum as well as tend to arrest the excessive radiation of heat and the evaporation of the moisture of the soil and subsoil. And this action would be cumulative, increasing with the years of tree growth, although there would not be so thick a bed of humus as is characteristic of the forest soil of regions having a larger and a more equable distribution in the rainfall. The larger amount of moisture held in the soil would have some effect in lowering the temperature of the air in the forest in the dry season, and to that extent would reduce the extreme annual range in temperature. In the rainy and colder season of the year the tendency would be to raise the minimal temperature and correspondingly to reduce the daily range. Of the effect upon the degree of general cloudiness and the consequent lowering of the mean daily temperature in the rainy season, there are no examples of afforestation on a large scale and under similar conditions which suggest any marked changes as at all probable. Our generalization relative to the agency of forest upon the formation of cloud and the amount of the rainfall and its seasonal distribution in any given area or region are altogether too vague, and even contradictory in some cases, to justify any statement to the effect that the total annual rainfall would be increased in any measurable extent by afforestation on so large a scale as is here suggested for this coastal-plain division of southern California. The great benefit in covering these treeless lands with forest would be in the increased storage capacity of the soil and subsoils for water, the reduction of the rate of evaporation from the soil surface and the consequent loss of the earth water to the dry superincumbent air, and, most important of all, in the equalization of the streamflow. And the increase in the number and in the size of the streams would make practicable the construction of many reservoirs for the watering of the adjacent arable valley lands.

Another potential element in a consideration of the question of afforestation is in the esthetic value of woodlands, particularly in clothing these bare and eroded hillsides and canyons with the greenery of trees. It may not be possible to make this coastal plain a land of water-brooks, but the many beautiful wooded hills when put in forest may add greatly to the landscape beauties of this most interesting country. The appreciation of values in the scenic charms of a country is certainly an element in its natural resources worthy of consideration and is one of its assets, as tangible and of as much economic importance as its climate. Afforestation would here add beauty to the betterment of climate.

The most important question in this problem of afforestation on so large a scale is its practicability. To cover these ranges of hills with forest from Santa Barbara to San Diego, having an aggregate area of more than two millions of acres, and many of them so rough and broken by erosion of the surface that they are almost inaccessible, is a work of great magnitude, demanding a most comprehensive plan, wide supervision of all the varying conditions of the labor to be performed, and a large outlay for the purchase of private property for the creation of nurseries, the construction of roads of access, the planting of suitable trees, their care and cultivation, and their protection against possible damages from fires, insect ravages, and other sources of danger incidental to forest. Of necessity it must be the work of either the National Government or of the State. As the accruing benefits of such an afforestation would be so largely regional, and even somewhat local in extent, it would seem to be properly a State undertaking.

Bulletins of the U. S. Forest Service and circulars of the State Board of Forestry give valuable and suggestive data in the planting of eucalyptus in California, and the utilization of the experience of many cultivators of the various species of this most remarkably successful imported tree is ready at hand for the use of the practical forester in the work of afforestation. It is altogether probable that some of the more valuable timber trees of the conifer group would be of service in making mixed plantations.

This afforestation on the large scale, as suggested in this paper, as a means of making the streamflow of these wild lands of value, of increasing the rainfall to a slight extent, and of reducing the losses of heat and moisture through evaporation, and thereby producing a slight amelioration of the climate, would in time yield a return in forest products which might in time be of sufficient value to pay in part the invested capital. Timber values can be computed with reasonably accurate estimates, even on so large a scale. If the investment were lacking in commensurate profit, the additional water supply for local use in the surrounding valleys would be a perennial source of wealth to the country. The enrichment in natural beauty and the attractiveness would constitute elements of public wealth in justification of so large a scheme of afforestation.

ORGANIZATION OF FOREST FIRE CONTROL FORCES

BY COERT DU BOIS

Contributed

A discussion of this one phase of the question of forest protection is like a treatise on the rear axle of the automobile—it must presuppose a great many accepted facts about the whole machine. It must presuppose, first of all, that the need for intensive fire protection has been determined, and that there exists a strong likelihood that fires will occur to an extent that will seriously interfere with the objects of forest management without systematic protection. The forest manager must determine to the owner's satisfaction—whether the owner is an individual, a corporation, or the people of the United States—just how much money the owner is economically justified in spending to secure the degree of fire protection necessary to accomplish the purposes for which his particular forest is being managed. These purposes may be either personal pleasure to be derived from forest landscapes, cash dividends derived from the sale of lumber, or public welfare derived from the maintenance of forests as sources of future lumber supply and as conservers of watersheds.

In a forest whose chief value is its beauty, as on a country estate, the owner may be justified in maintaining a protective organization designed to control each fire within an area of 10 square feet. A lumberman, figuring on the likelihood of fires starting in his uncut stumpage and the reduction in cash value to his logs each fire will cause, may figure he is justified in financing a protective system which will keep each fire under 40 acres.

Fire protection, in short, is justified only to the extent to which it secures the product of each forest area, whether that product is wood, the flow of streams, tan-bark, game, or the health and pleasure of a group of people. It can cost anything less than the value of the products secured with it that would not be secured without it; but if it costs any more it is neither good business nor good forestry.

Almost the first thing the forest manager must do, then, is to determine how much protection it is good business for the forest owner to have.

In the National Forests in California it has been determined from past performances in protection, from the values produced, and from protection costs that holding the average acreage per fire down to 10 acres on lands capable of producing timber and down to 100 acres in brush lands constitutes a reasonable degree of immunity from fire loss. This determination was in part empirical and in part arbitrary. It stands until there can be demonstrated by study and test what degree of protection can be delivered for a given sum under known conditions; what amount expended in protection will be most to the public interest, and a correct measure of the protection which that amount of money should secure.

UNITS OF THE FORCE

To reach any given standard of protection efficiency will always require human labor. No one is going to devise an economical automatic sprinkler system for vast forest areas. The work these men must do consists in planning and executing protecting campaigns; in out-guessing the originators of fires in as many cases as possible; in detecting each fire that does start as soon as it starts; in getting word of it to the right man, and in constructing the shortest possible fireproof barrier around it. These operations call for physical, mental, and temperamental qualities of a very high grade. The ideal man for this work should be possessed of ordinary bodily strength and endurance, but he *must* have entire freedom from any chronic disability that may incapacitate him when he is needed, which may be at any time of day or night during the entire fire season.

The mental equipment of this ideal man—not his education or training, but the kind of mind best suited to the work—should include the faculty of quick and accurate guessing rather than the ability to come to a right conclusion by the process of conscious reasoning of each logical step; or, as Münsterberg[1] puts it in speaking of the ideal man for ship service:

> "Of course, besides these two types there is the third type, the desirable one, the men who in the unexpected situation quickly review the totality of the factors in their relative importance and with almost instinctive certainty immediately come to the same decision to which they would have arrived after quiet thought."

Temperamentally he must have the capacity for intense enthusiasm for the fire-fighting game. Fire protection has all the elements of good work and of good play, too. Dr. Cabot states[2] these elements splendidly—"difficulty enough to call out our latent powers of mastery, variety balanced with monotony, a chance to achieve, a title, connection with a cause which we can loyally serve, congenial comrades in work; these are the elements of the good job." Of good play Dr. Cabot says:

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[1] Hugo Münsterberg: "Psychology and Industrial Efficiency," Chapter IX, page 85.

[2] Richard C. Cabot, M. D.: "What Men Live By," Chapters IV and XVI.

> "* * * It has a clear-cut form and organization. It may use rhythm and repetition, but subordinates them to improvisation and adventure. It gives intense and varied delight, but in such dynamic form that pleasure is ever quickly lost and found again. It is full of give and take. * * *"

The best man for forest-protection work need not have the ability to state this, but he must have the temperament to feel it. The practical value of these elements of attractiveness in this line of work is the fact that because of them better men for the money can be secured. The work itself is a part of the compensation to just the sort of men who are temperamentally best suited to it.

RATES OF PAY

In spite of its strain and responsibility, protection work possesses an attractiveness which makes it possible to secure good men at a compensation somewhat under the strict competitive figure. An extreme example of the effect of this very real but intangible edge over other more humdrum lines of work is the army. Men will enlist knowing that they must undergo deadly barrack routine or, if called into active service, fatiguing labors and the risk of death for $13.65 per month.

To a limited extent only the forest manager must meet the competition of other employers of labor of equal intelligence and for similar periods of service in the locality. If in fixing his compensation he takes into consideration in a broad way the earning capacity in other lines of the kind of man he wants and then adopts a fixed rate intended to cover the man's time, the equipment he must furnish, the isolation of his station, and the strain and responsibility he must undergo—this standard rate being published, if it is a right one, will attract the right kind of men.

Except for the supervisory officers, protection work is necessarily intermittent, varying from two to eight months in the year. The good man who comes back next season is worth far more than a new man. Applicants who live near the forest and who have other interests or work that will bring them in an income during the season of no fire danger should be given the preference. The ideal is to build up a resident protection militia, each member of which has had several seasons' training in the work and is available for service in the regular force every fire season.

PERIOD OF SERVICE

It is trite to say that the greatest number of men should be on duty during the period of greatest fire danger. That is as self-evident as saying two men can finish a job in half the time it will take one man. But the very direct relation between the right period of service and the intensiveness and cost of the protection rendered is often lost sight of. Suppose the danger period is assumed to be four months, or 120 days, and at an average rate of $2.80 per day 10 men can be employed with the protection funds available. If a study shows that the force is actually needed for 100 days rather than 120 days, 12 men can be employed for the shorter period with the same total.

For a forest region cursed with a regularly recurring dry season, a study of past climatological records will lead to the establishment of a normal dry season. For this normal the organization must be designed and financed, and departures from the normal which increase the fire danger must be considered as emergencies to be handled by an emergency reserve organization paid for on a per diem basis out of an emergency contingent fund.

Within the normal dry season the fire danger is not a fixed quantity. It increases in intensity with advancing time since the last rain. For the purpose of determining the rate at which the protection force should be built up, or how the total funds available for salaries can be distributed in man-days so as to secure the closest correlation between the number of men on duty and the degree of fire damage present, three curves may be platted on cross-section paper. The paper is divided vertically into units, which represent one fire, one acre, and one man; horizontally into 10-unit spaces, representing 10-day intervals during the normal dry season for the locality. From all available trustworthy records of past seasons, the average number of fires per 10-day interval is platted and a curve or graph drawn. Then, for the same period, the *average* total acreage burned over in each 10-day interval is platted and curved. These will not normally parallel, because the factors which influence the likelihood of fires starting at various times of the year are not the same factors which influence the rate at which fires spread. Even though the same or a higher number of fires occur during the early part of the season, their rate of spread is slower, and a longer time between start and control may elapse with the same acreage burned over. All of which means that fewer men can maintain the same protection standard in the earlier part of the season. A careful study of the two curves will enable the forest manager to plot a third curve or graph in relation to the other two to represent the number of men that should be on duty in every 10-day period. The relation of this curve to the others is not a mathematical one. The sum total of salaries it calls for is limited by the fund available for that purpose. The whole process is but a judgment check—a guide which helps toward establishing the right relation between number of men, periods of service, and the degree of fire danger.

FUNCTIONS OF THE FORCE

Accepting Webster's excellent definition that organization is the act of arranging in a systematic way for use or action, the forest manager, having stated in concrete terms what action he wants performed, must plan beforehand what part every unit of his organization is to take in the performance of it. He wants each fire to be put out within a stated area. For a given time of year and under normal conditions this can be done successfully only within certain limitations of time. Within this time limit the fire must be discovered and its location ascertained; the essential facts in regard to it must be communicated to the man or men who are to control it; this man or these men must procure proper equipment and move from their then position to the point of the fire; he or they must then construct enough of an unburnable barrier around it to stop its spread. Because all of these processes must be completed within a fixed limit of time, arrangements which will insure great celerity of action are essential to successful protection organization. As an aid to determining the degree of speed necessary for each process, the elapsed time between start and control may be divided into four periods:

(1) Discovery time—or from the minute of start to the minute of location. This includes time taken in detection.

(2) Report time—or from the minute of location to the minute of receipt of report by the man who is relied upon to control the fire. This includes time taken in transmitting all information.

(3) Travel time—or from the minute of receipt of report to the minute work is started on the fire. This includes time taken in securing tools, equipment, or supplies, and in moving to the point of attack.

(4) Control time—or from the minute work is started to the minute fire ceases to spread in area.

To get the sum total of allowable time for all these processes, reliable information must be at hand on the normal rate of spread of fires in every part of the forest (every ground-cover type) under each set or combination of slope, wind, dryness, and heat conditions; also for each must be known the rate of speed at which a man can construct an unburnable barrier; or, to state it differently, the maximum size of a fire one man can successfully handle.

In addition to controlling fires that start, the organization is depended upon to reduce the chance of their starting. This is effected by the presence of a member of the organization at a time and place where, without his presence, a fire would start through human agency. This deterrent or warning influence may, of course, be extended beyond the point he actually occupies, and as a matter of fact generally is, as when a patrolman, because many campers know he is riding the trail, prevents the leaving of unextinguished camp-fires along an extended route of tourist travel.

The whole organization must be kept in communication. It must be kept supplied with the facilities for doing its work. It must be geared up so that each unit knows what part it is expected to play and what parts other units will play. Team-work must be guaranteed; or, in short, it must be supervised.

The functions of the protection force may be stated, then, as supervision of protection work, prevention of fires starting, detection and control of those which start.

SUPERVISION

"The ideal point for the lodging of any administrative function and the resting of the corresponding responsibility is where the problem of keeping in touch with the details of the agencies of the action controlled is approximately equal in difficulty to the problem of keeping in touch with the general plan of which that action is a part."[3]

Applying this principle of Professor Jones to the general fire protection machine, it is clear that the individual patrolman or forest fireman is too much concerned with speed and action along the route or within the compartment for whose safety he is held responsible to keep sufficiently in touch with the workings of the whole protection plan. His is a distinct area responsibility rather than an organization responsibility. On the other hand, the manager of the forest, while entirely responsible for the general protection plan, cannot know enough of the details of topography, risk, and cover in each compartment to direct efficiently the details of the performance of the action in each.

The solution is an intermediate officer whose function is supervisory. He bears the same relation to the units of the control force and the manager as the troop sargeant does to the troopers and the cavalry captain. Whether he is in immediate charge of two, five, or ten compartments (or control divisions, as they are called on the California National Forest) is a matter determined by the intensiveness of the protection system. Since the organization in the forest usually has still other work to perform besides protecting it, this function is most economically lodged with the field officer serving the year round, whose duty it is to perform some and supervise all of the work other than fire protection in a given area. Such an officer is found in the district ranger on the National Forests.

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[3] Prof. Edward D. Jones: "Business Administration," page 70.

PREVENTION

The presence of every forest officer in the woods is a potential deterrent of fires starting from human agency; but this deterrent effect can be intensified by systematization. The poacher hesitates to slip into a game preserve where he knows an armed keeper is patrolling; but if he knows the keeper is walking up and down in the only place of egress, he does more than hesitate—he doesn't go. A similar object is what one portion of the control force is to effect—*i. e.,* to make fires not start. This object cannot be fully accomplished by casually placing men about and trusting to their general deterrent effect; it takes active work to accomplish it.

Outside of lightning, forest fires start in connection with certain human activities. It is almost hopeless to control the actions of all individuals in the forest, but it is by no means impossible to exercise an effective control over the activities of groups of individuals. The rigging slinger in a logging job cannot be prevented from rolling a cigarette while waiting for the back line to drag out the choker after a trail-in; but if a high degree of fire protection coöperation exists between the agency responsible for it and the lumber company, the rigging slinger will throw the butt of his cigarette in the dust and step on it.

The forest traveler, who often does not know his own destination, whose purposes may be fishing, crossing the range, or painting scenery, who may follow any one of a number of routes, and who is directly responsible to no one while in the woods—his is the most difficult activity to control, and statistics show that he causes more fires than any other class.

Difficulty of control therefore varies directly with the degree of organization of the activity in connection with which fires are set and the definiteness of the territory which it occupies. Forest officers whose responsibility it is to prevent fires starting must work toward organizing and localizing the human risk.

The officers who are relied upon to perform this function must, very often, be continually on the move. Upon this mobility depends their success at this work, but it also precludes their keeping in communication with the officers who are relied upon to detect fires. Where the need of a forest patrolman exists to control an unorganized human element likely to start fires, he cannot and should not be relied upon for any other primary protection function. If he is to be an effective patrolman, he can be little else but a reserve fire-fighter.

DETECTION

With almost any standard of protection determined upon, the time limitations are such that systematic arrangements must be made for the detection and location of each fire within a very few minutes of its start. The conception is obsolete of the forest ranger "riding his beat" and warning the camper about his fire, discovering a fire burning when in the course of his patrol he comes upon a commanding point, and then hastening to it and putting it out.

A city fire department does not have its men patrolling the city streets looking for fires to put out. It establishes a perfect communication system, and then each unit waits in the center of its area of responsibility until a fire is reported to it; then it loses no time getting there. In a city of 20,000 inhabitants there are 20,000 fire detectors, each ready to report by a fool-proof system the location of each fire that starts.

In a forest the detection system must be provided as a part of the protection organization. Its function is to discover, locate, and report accurately and in the shortest possible time each fire that starts. Each unit of it can do so when the entire area dependent upon it for discovery is visible, when it is furnished with locating devices and is in complete communication with the rest of the organization, and when it is continuously manned. Unlike a city fire, a forest fire makes a clearly distinguishable cloud of smoke as soon as it starts. A properly correlated chain of lookout stations insures speedy detection and is not necessarily very expensive. Considering the gains in discovery time and report time, it is far cheaper than depending on haphazard detection by moving patrolmen or unsystematic service by voluntary observers.

CONTROL

A forest patrolman, to accomplish fire prevention, must be on the move. A forest lookout, to accomplish fire detection, must be at his station all the time, even when a fire occurs.

A third group of the protection force must be depended upon to proceed to each fire and put it out. The units of this group, in the California National Forests, are called forest firemen, and their headquarters control stations.

The degree of intensiveness the whole protection system is to render depends, more than upon any other one factor, on the location of these control stations. Upon their number and upon their relations to each other and to the topography and possible travel routes of the forest depend the time consumed in proceeding to a fire. This period—travel time—is the longest and therefore the most important of the first three elapsed time periods. It should be the longest of all four, but "control time" is indeterminate.

The forest manager must approach the question of selecting the points for control stations armed with a knowledge of where, in his forest, the fires are going to occur; how much time will elapse between the minute they reach detectable size and the last minute one man can control them, and the rate at which the forest fireman can be depended upon to travel. Given these three facts—which may be obtained from a study of past fire causes and present risk factors, from studies on the rate of spread of fires, and from a knowledge of the topography and cover—the forest manager can determine, first, the boundaries, and, second, the time centers of his control divisions. The time center is not the point from which every other point in the division can be reached in the shortest time, but the point from which every other point *where fires may be expected to occur* can be reached within the limit of time that will allow their being controlled by one man.

In a mountain forest it will be almost invariably found that the theoretical time center can be modified to secure intensification of the lookout service without defeating the purpose of the location of the control station. Small areas in the heads of gulches on the back sides of ridges will always be invisible to the lookout, even though, broadly speaking, the whole control division is under his eye. Very often the control station can be so located as to afford a view into just the country the lookout cannot see.

Facilities with which to move in the quickest possible way in any direction through his division should be furnished the fireman at his station. These may be gasoline, oil, and a motorcycle; hay, grain, and a horse, or simply a pair of hobnailed shoes. Nothing (but a few dollars difference in cost) is gained by departing from the right location of a control station in order to get pasturage for the forest fireman's horse.

DIVISION PLANS

The place for the protection plan is not in a file-case in the forest manager's office, but in the division control station. When a fire breaks out the fireman wants to know where it is and in what direction and how hard the wind is blowing at the fire. He wants to know the quickest route to the fire, what kind of cover it is burning in, and how fast it is spreading. He wants to know what road, trail, or open ridge is the nearest base for locating his fireproof barrier. He wants to know where the telephone station nearest the fire is, where the line runs, and who can be called over it. All these things he should know before he leaves his station for the fire. He cannot spare the time from fighting it to find out any of them.

The purpose of the division plan is to give the division fireman all of the facts he needs to know about a fire to fight it most effectively; to give them to him instantaneously and before he leaves his station. He wants these facts for three reasons—to know what to take, which way to travel, and just where to start the most effective work the minute he arrives.

The forest manager may set about making the protection plan for a control division first by cross-sectioning a large-scale map of it into squares—2½ acres (5 chains on a side) if his protection is to be very intensive, or 40-acre squares if it is extensive. He may then undertake cover and rate of fire-spread studies for each square; work out the quickest travel route to each from the control station; determine from correlated wind studies the direction and velocity it will be blowing in each square for a given direction and velocity of wind at the lookout station which serves the division.

These maps and this information in tabular or graphic form, tacked on the wall beside the telephone instrument in the station of every unit of the control organization, should make a fairly complete "arrangement in a systematic way" for the action of fire control in the forest.

SOME OBSERVATIONS ON THE VARIATION IN LENGTH OF CONIFEROUS FIBERS[1]

BY H. B. SHEPARD AND I. W. BAILEY

Contributed

In 1867 Sanio[2] conducted an investigation on the variation in the size of tracheids in scots pine (*Pinus sylvestris* L.). From his work he deduced five general laws. The first of these says: "In the cross-section of a stem or branch the tracheids increase in size for a certain number of annual rings until a maximum is reached, after which the size remains constant." The figures he gives show this to be true for scots pine, though the constant size reached and the number of rings required to reach it varies in his different specimens. His second law says: "The final constant size of the tracheids in the stem varies at different distances from the ground, first increasing until a maximum is reached and then decreasing toward the top." He also gives a modified form of this law: "The size of the tracheids in a given annual ring in the stem increases from the ground upward until a maximum is reached, after which it decreases toward the top." Sanio's three other laws are concerned with the variations in the dimensions of tracheids in roots and branches.

The results of Sanio's investigation have been accepted and widely quoted, but it seems desirable to test the general applicability of his laws by the study of the behavior of tracheids in other conifers. The writers have studied the stems of the following American species: *Pinus strobus* L., *P. palustris* Mill., *Picea rubens* Sarg., *Tsuga canadensis* Carr., and *Abies concolor* Lindl. and Gord. In making the investigation the following points were noted: The variation in length of tracheids in succeeding rings of the cross-sections of stems; the variation in length of the tracheids of an annual ring at various heights in the stem, and the influence of the width of annual rings and "rothholz," compression wood, upon the length of tracheids.

In the laboratory blocks were cut radially from the cross-sections and chips taken from every tenth ring. Maceration was accomplished by the use of a 5 per cent solution of equal parts of chromic and nitric acid.

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[1] Contributions from the laboratory of Wood Technology of the Harvard School of Forestry, No. 3.

[2] Jahrbücher d. Wisch. Botanik, Vol. VIII, page 401.

The "fibers" were separated after maceration by shaking with water and glass beads, insuring minimum breakage. They were then kept in a mixture of 95 per cent alcohol and chloroform to prevent softening. The actual measurements were made with a micrometer eye-piece, fifty measurements from each chip. Maxima, minima, and averages were recorded.

The material for the study of the relation of ring width was obtained from different parts of the annual rings of an eccentric stump of *Pinus strobus.* The material for the comparative study of normal stem wood and "rothholz," or compression wood, was obtained similarly from different parts of the same annual rings.

The results are shown in the following tables:

EFFECT OF AGE ON THE LENGTH OF TRACHEIDS

Table 1.—***Pinus strobus, 120 annual rings, cross-section 1 foot from ground***

Annual ring.	Fiber lengths—millimeters.			Annual ring.	Fiber lengths—millimeters.		
	Max.	*Min.*	*Ave.*		*Max.*	*Min.*	*Ave.*
20...........	3.35	1.60	2.65	80...........	5.10	2.65	3.77
30...........	3.65	2.35	3.02	90...........	4.60	2.50	3.79
40...........	4.80	2.55	3.64	100...........	4.65	2.50	3.85
50...........	4.20	2.35	3.30	110...........	4.45	3.20	3.91
60...........	4.65	2.45	3.47	120...........	5.40	3.45	4.20
70...........	4.80	2.65	3.52				

Table 2.—***Abies concolor, 80 annual rings, elevation of cross-section unknown***

Annual ring.	Fiber lengths—millimeters.			Annual ring.	Fiber lengths—millimeters.		
	Max.	*Min.*	*Ave.*		*Max.*	*Min.*	*Ave.*
10............	3.50	2.20	2.75	50............	5.45	3.30	4.45
20............	3.90	2.40	3.30	60............	5.45	3.55	4.64
30............	4.90	2.50	3.65	70............	6.30	3.50	5.02
40............	5.65	2.15	3.58	80............	6.45	3.55	5.20

Table 3.—***Pinus palustris, 230 annual rings, cross-section 1 foot from ground***

Annual ring.	Fiber lengths—millimeters.			Annual ring.	Fiber lengths—millimeters.		
	Max.	*Min.*	*Ave.*		*Max.*	*Min.*	*Ave.*
10...........	3.00	1.80	2.42	130...........	5.90	3.90	4.99
20...........	3.85	2.40	3.06	140...........	6.25	3.75	4.92
30...........	4.50	2.80	3.70	150...........	6.00	4.00	4.87
40...........	4.95	2.80	4.06	160...........	6.20	4.00	5.08
50...........	5.30	2.95	4.11	170...........	6.05	3.45	4.57
60...........	6.05	3.05	4.33	180...........	5.75	3.40	4.10
70...........	5.25	2.85	3.92	190...........	5.50	3.10	4.03
80...........	5.70	3.05	4.41	200...........	6.20	3.15	4.42
90...........	6.05	3.20	4.66	210...........	6.05	3.35	4.66
100...........	6.30	3.45	4.88	220...........	5.90	3.10	4.35
110...........	6.05	3.60	4.57	230...........	5.20	2.85	4.00
120...........	5.80	3.85	4.66				

Table 4.—*Tsuga canadensis, 80 annual rings, cross-section 1 foot from ground*

Annual ring.	Fiber lengths—millimeters.			Annual ring.	Fiber lengths—millimeters.		
	Max.	*Min.*	*Ave.*		*Max.*	*Min.*	*Ave.*
10	2.30	0.95	1.63	50	4.25	1.85	3.17
20	3.20	1.15	2.20	60	3.80	1.60	2.48
30	3.75	2.05	2.99	70	3.20	1.40	2.47
40	4.00	2.25	3.16	80	3.15	1.80	2.84

EFFECT OF POSITION IN THE VERTICAL AXIS ON THE LENGTH OF TRACHEIDS

Table 5.—*Picea rubens, 50 annual rings, average fiber length, millimeters*

Annual ring.	Distance from ground—feet					
	1	6	12	18	24	30
10	1.68	....	....	....	....	....
20	2.21	2.49	2.22	....	....	....
30	2.58	2.92	2.84	2.49	1.89	....
40	3.17	3.00	3.48	3.31	3.23	2.71
50	3.48	3.56	3.84	3.70	3.87	3.31

EFFECT OF WIDTH OF RING UPON THE LENGTH OF TRACHEIDS

Table 6.—*Pinus strobus, eccentricity due to faster growth on one side, average fiber length*

Annual ring.	Fiber lengths—mm.	
	Narrow.	*Wide.*
10	1.63	1.66
22	2.58	2.41
27	2.51	2.53
Average	2.24	2.20

COMPARATIVE LENGTH OF TRACHEIDS IN NORMAL STEM WOOD AND IN COMPRESSION WOOD, OR "ROTHHOLZ"

Table 7.—*Pinus strobus, eccentric stump, average fiber length*

Annual ring.	Fiber lengths—mm.	
	Rothholz.	***Zugholz.***
7	2.02	2.16
11	2.52	2.60
6[3]	1.86	2.02
Average	2.13	2.26

[3] Second specimen.

SUMMARY AND CONCLUSIONS

1. *The Effect of Age on the Length of Tracheids*

The results obtained are not in accordance with Sanio's first law, since no constant maximum figure was found in the specimens examined. Inasmuch as Sanio found a constant in all cases within the 50th ring, and

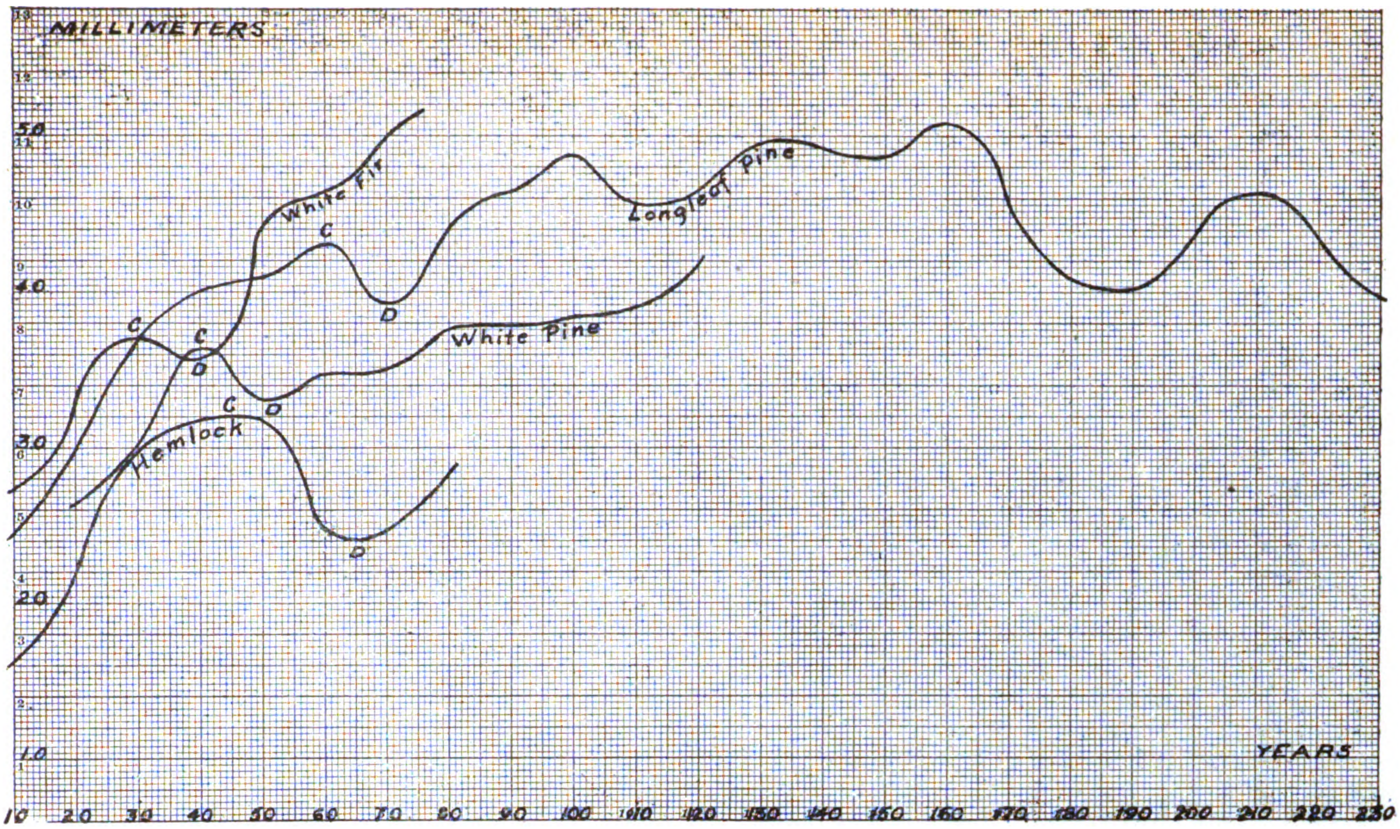

FIG. 1.—DIAGRAMMATIC REPRESENTATION OF THE VARIATION OF AVERAGE TRACHEID LENGTH WITH AGE.

in one case within the 20th, and this study found none, even within the 230th, it is evident that Sanio's first law cannot be applied generally to conifers.

As is shown diagrammatically in figure 1, tracheid or "fiber" length increases rapidly, in each of the species examined, for a period varying in length from 25 to 60 years. At the end of this period (*c*) there is a marked falling off in the length of the tracheids which lasts for a decade or more. (*d*) Subsequently the tracheids again increase in length. In the case of the longleaf pine, which unfortunately was the only old material available, a maximum average length occurs finally at 160 years, and is followed in the older rings of the tree by a comparatively rapid decrease in the length of the tracheids.

2. *The Effect of Position in the Vertical Axis*

It is evident from Table No. 5 that Sanio's second law, as he presents it in a modified form, is applicable to *Picea rubens* as well as to *Pinus sylvestris*. A fact unnoted by him is that the maximum tracheid length occurs higher from the ground in rings nearer the bark. This probably bears a relation to the fact that each successive annual increment is larger—*i. e.*, extends farther from the ground.

3. *The Effect of Ring Width on Tracheid Length*

The study of the eccentric cross-section seems to indicate that there is no close relation between width of ring and "fiber" length. A classification according to width of the rings of *Pinus palustris* was attempted to trace such a relationship, but no positive evidence could be obtained.

4. *The Effect of the "Rothholz" Condition*

The "fibers" in the "rothholz" were found to be consistently shorter than those in the tension wood, or "zugholz," of the same annual rings of a cross-section. The specimens examined (Table 7) show a fairly constant shorter average tracheid length in the "rothholz" side—results similar to those obtained by R. Hartig[3] in his investigation of "rothholz."

5. *The Determination and Value of "Average Fiber Lengths"*

Average fiber lengths for different species of plants are published from time to time, and have even been used as a basis for the identification of woods of economic importance. It is well perhaps to emphasize certain difficulties which arise in the determination and use of average fiber lengths. As has been shown above, fiber length varies to a marked degree in different regions of a plant. Therefore, average fiber lengths determined from material taken from a given region of a tree are not representative of a species. The average fiber length for a pulp mill working in young second-growth spruce may be quite unlike that of a mill working in old mature timber. Furthermore, two pieces from the same tree submitted for identification may vary considerably from the average fiber length of the species. It is, accordingly, evident that "average fiber lengths" are of relative value and often of doubtful significance for purposes of identification.

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[3] R. Hartig. Holzuntersuchungen, p. 64. Julius Springer, Berlin, 1901.

It seems to be desirable that an examination be made of the cross-sections of old trees in order to secure further evidence in regard to the following points: Is there a uniform rapid increase in tracheid length during a period which corresponds roughly to the period of most rapid height growth? Is the first marked decrease in fiber length associated with the retardation of height growth? Does tracheid length increase gradually, with various fluctuations, until the tree reaches maturity? Does tracheid length decrease with corresponding irregularities during the senile stages of the tree's life history?

The writers are indebted to Mr. J. S. Rogers and Mr. Knower Mills for material of longleaf pine and white fir.

A CONSPECTUS OF NORTH AMERICAN FIRS (EXCLUSIVE OF MEXICO)

BY WILLIAM H. LAMB

Contributed

Few of our native trees are so definitely segregated by anatomical characteristics as North American species of *Abies.* Many other trees are not distinguished by a single structural difference, but by the combination of numerous small but constant characters. In our native firs, however, each specific form is definitely distinguished from its nearest relative by some positive structural difference. The purpose of this paper is to so define and illustrate the distinguishing characteristics of North American firs, exclusive of Mexico, that this important group, often regarded as difficult, may be easily distinguished by forest officers.

DESCRIPTION OF GENUS

The firs are evergreen trees with branches arranged in whorls and with the bark of the trunk containing numerous "resin blisters," when young. The leaves are narrow, flat or four-sided, sessile, spirally arranged around the twig, but by a twist at base appearing as if in two rows; in cross-section showing two resin ducts close to the lower surface of the leaf, or in some species up in the pulp of the leaf, remote from either surface; with stomata on lower surface, or in some species on both sides; persistent for five to ten years, leaving round, flat scars when falling. The cones are erect, forming only on the upper side of the topmost branches; with thin scales which, with their inclosed or protruding bracts, fall away in autumn, leaving the central spikelike axis attached to the twig. The seeds, two of which are borne under each cone-scale, are winged, and contain resin cells, which may be seen by cutting into the seed coat.

UNRELIABLE CHARACTERISTICS

It is important in any consideration of the distinguishing features of a group of trees to pick out and disregard those characteristics which are so variant that they would be of no value as a means of identification. Such features as the color and shape of the cone-scales and color of foliage may be so disregarded. In general, cones of *A. amabilis* and *A.*

lasiocarpa are purple, while those of *A. grandis* and *A. concolor* are green, but the variation in color from dark green to purple, and even yellow, practically destroys the value of such a distinction. The shape and size of the cone-scales is a characteristic which is not even constant among scales from the same cone and is therefore of little value, except in distinguishing our two eastern species, *A. balsamea* and *A. fraseri,* where the cones are very much smaller than typical cones of any of the western forms.

RELIABLE CHARACTERISTICS

The form of the cone-bract is of the greatest importance as a distinguishing characteristic. This appendage in some species is quite minute and rudimentary, while in others it is conspicuously developed. As abnormal forms have been found in which the cone-bracts were transformed into perfect leaves and the axis of the cone prolonged into a branchlet with ordinary foliage, this bract may be regarded as a metamorphosed leaf. It is probable, therefore, that those species with included cone-bracts have been evolved from forms with exserted bracts, and that the direction of evolution among the firs has been toward a reduction of the cone-bract. *A. venusta* (fig. 7), with its cone-bract prolonged into a long leaf-like awn, is probably the most primitive of North American firs, and should be regarded as the last and disappearing representative of an ancient form.

In general the *relative lengths of the cone-scale and the bract* furnish a dependable means of distinguishing certain species. However, the value of the protrusion of the cone-bract as a factor in the identification of our native firs is considerably lessened by the occurrence of forms of *A. balsamea* with slightly exserted bracts and forms of *A. shastensis* with abortive bracts.[1] In the case of the eastern species, these forms need cause no confusion, as the bracts are not different in shape from the included form (fig. 1) and are neither spatulate nor reflexed as in *A. fraseri* (fig. 2).[2] In the case of *A. shastensis,* the variation in the relative lengths of the cone-scale and the bracts often causes considerable confusion, and even doubt as to its being a distinct form. As in the case of *A. fraseri* in the east, the impression exists that the protrusion of the cone-bract is the character upon which it is maintained as a species, but it is not the protrusion of the bract so much as its form that should give to Shasta fir its specific rank. The cone-bracts of *A. magnifica* (fig. 8), although slightly constricted at the base, are not enlarged, but acute at the apex, while the cone-bracts of *A. shastensis* (fig. 9), like those of *A. nobilis* (fig. 10), are spatulate or enlarged at the apex. The cone-bracts of *A. nobilis* (fig. 10) have longer and stronger points than those of *A. shastensis,* but in this instance it is better to refer to the foliage distinctions.

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[1] A Synopsis of the Red Firs: W. H. Lamb, Proc. Soc. Am. For. Vol. 7, No. 2, pp. 184-186. 1912.

[2] Drawings and discussion of cone-scales of *A. balsamea*, *A. fraseri*, and *A. lasiocarpa* contributed by the writer in U. S. Department of Agriculture Bulletin 55, Balsam Fir, by Raphael Zon.

The cone-bracts of *A. lasiocarpa* and *A. amabilis* may be distinguished from those of *A. grandis* and *A. concolor* by their long points, and from each other by the character of these points. In *A. lasiocarpa* (fig. 3) the point of the bract is slender and narrow, while in *A. amabilis* (fig. 4) the point is stout and broad at the base.

The arrangement of the leaves on the twigs is a very useful and important consideration in the determination of certain species and in the identification of specimens without cones, where every foliage characteristic must have consideration. The leaves of all firs are scattered around the stem, but by a twist at the base they often appear otherwise. This characteristic is most useful in distinguishing leaves of *A. amabilis* and *A. grandis,* where the position of the resin ducts in the leaf is the same (fig. 11) and where no stomata are found on the upper surface of the leaves. Without cones the arrangement of the leaves on the twigs becomes the only definite means of distinction between these two species. In *A. amabilis* the leaves, by a decided twist at the base, appear as if growing from two sides and the top of the twigs, while in *A. grandis* they appear as if growing only from the two sides.

There are two cases where species cannot be distinguished by leaf characteristics and one instance where species cannot be recognized merely by the form of the cone-bract. The two eastern species (*A. balsamea* and *A. fraseri*) cannot be separated by leaf distinctions, but are only recognized by the form of the cone-bracts. This is also the case with the two western species (*A. magnifica* and *A. shastensis*). Like the two eastern forms, they cannot be distinguished from foliage specimens. These two species, very closely related and generally regarded as doubtfully distinct, are only recognized by cone differences. The only instance where forms cannot be distinguished by the form of the cone-bract is in the case of *A. concolor* and *A. grandis.* The cones of these species cannot be distinguished, and the only anatomical difference is the presence of stomata on the upper surface of the leaves of *A. concolor* and the absence of stomata on the upper surface of the leaves of *A. grandis.* Obviously, then, it is impossible to arrange a key that is based entirely upon foliage characteristics or entirely upon consideration of the leaves.

In the following key, in which *A. venusta* has been omitted on account of its local distribution, all of the species which may be definitely distinguished by leaf characteristics are included, while in the succeeding key to North American species the forms of the cone-bract have been made the basis of distinction and the leaf characters only employed where no cone differences are to be found.

- I. Leaves flattened.
  - A. Leaves with stomata on upper surface.
    - 1. Resin ducts large, up in pulp of leaf............. *A. lasiocarpa*
    - 2. Resin ducts small, close to lower margin.......... *A. concolor*
  - B. Leaves without stomata on upper surface.
    - 1. Resin ducts small, close to lower margin.
      - *a.* Leaves appearing as if growing from both sides and top of twigs.................... *A. amabilis*
      - *b.* Leaves appearing as if growing from the two sides of the twigs........................ *A. grandis*
- II. Leaves thickened, more or less 4-sided.
  - A. Leaves with stomata on upper surface.
    - 1. With groove in upper surface.................... *A. nobilis*
    - 2. Without groove in upper surface................. *A. magnifica*

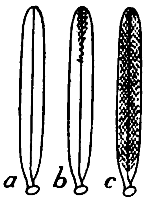
The position of the resin ducts in the leaf is an important and constant characteristic. These little tubes, running the length of the leaf, are found in two positions. Either they are located up in the pulp of the leaf or they are found close to the lower surface and near the margin of the leaf. A third position may be discovered in the flattened leaves of the lower crown branches of the quadrangular-leaved forms (*A. nobilis, A. magnifica,* and *A. shastensis*), where these ducts are close to the lower surface, but remote from the margins.

Of particular importance in distinguishing *A. lasiocarpa* is the characteristic size and position of its resin ducts. Here the ducts are very large and located up in the pulp of the leaf (fig. 12), as is the case with the two eastern species (*A. balsamea* and *A. fraseri*), while in *A. concolor, A. grandis,* and *A. amabilis* the ducts are smaller and located near the lower margin of the leaf (fig. 11). In *A. lasiocarpa* these ducts are so large that they may be observed without the aid of a hand lens. In fresh material of all species it is possible to determine the position of the resin ducts by pressing between the fingers a leaf which has been cut across, as two tiny drops of resin will exude from the opened ends of the ducts, plainly indicating their position.

The character of the upper surface of the leaf becomes an important factor in distinguishing certain species, the presence or absence of stomata on the upper surface of the flat-leaved species and the presence or absence of a groove in the upper surface of the leaf being characteristic of certain species. Stomata may be observed with a hand lens or often by the naked eye, as a band or series of fine dotted lines running longitudinally along the leaf. Stomata are found on the lower side of the leaves of all species, but as they are absent or very rare on the upper surface of the leaves of *A. grandis* and *A. amabilis,* this characteristic becomes of considerable value, especially in distinguishing *A. grandis* from *A. concolor,* the leaves of which are distinctly stomatiferous on their upper surface.

A. concolor and *A. grandis* are very closely related, especially in California and Oregon. The Rocky Mountain form of *A. concolor* is the type of the species, while the California form is the variety *lowiana* Lemmon. In the Del Norte region of California and in southern Oregon these forms run closely together. Trees are found which are difficult to distinguish except as intermediate between the California form of *A. concolor* (*A. lowiana* Murray) and *A. grandis.* Explanation of these intermediate forms will be found in the fact that the California form of *A. concolor* is intermediate between *A. grandis* and the Rocky Mountain form of *A. concolor.*

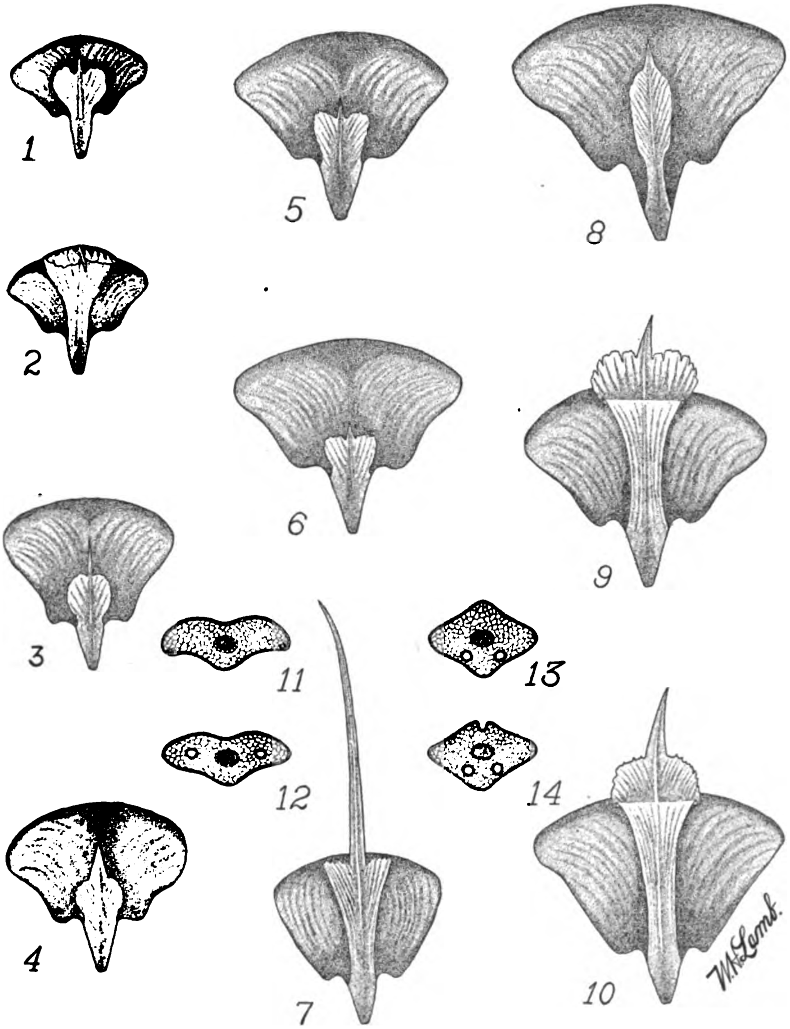
The leaves of *A. concolor,* including the California form, are conspicuously stomatiferous on their upper surface (text fig. 1*c*), while the upper surface of the leaves of *A. grandis* are without stomata (text fig. 1*a*). As no cone differences are to be found between these closely related forms, this characteristic furnishes the only structural difference by which they may be recognized. In the leaves of the forms which are intermediate between *A. grandis* and the California form of *A. concolor* the stomata are confined to the apical portion of the leaf, or especially in the upper crown branches extending down toward the base of the leaf, but confined to the groove (text fig. 1*b*). Such forms are here referred to *A. grandis.*



TEXT FIG. 1.

Key to North American species

I. Eastern species.
  A. Bracts ovate, shorter than cone-scales (fig. 1).... (1) *A. balsamea*
  B. Bracts spatulate, reflexed, longer than cone-scales (fig. 2).. (2) *A. fraseri*
II. Western species.
  A. Bracts ovate, shorter than cone-scales.
    1. Bracts with long points.
      a. Bracts with narrow, slender points (fig. 3) .... (3) *A. lasiocarpa*
      b. Bracts with stout, broad points (fig. 4).. (4) *A. amabilis*



A CONSPECTUS OF NORTH AMERICAN FIRS.

Cone-scale and bract, natural size: (1) *Abies balsamea,* (2) *A. fraseri,* (3) *A. lasiocarpa,* (4) *A. amabilis,* (5) *A. grandis,* (6) *A. concolor,* (7) *A. venusta,* (8) *A. magnifica,* (9) *A. shastensis,* (10) *A. nobilis.*

Cross-section of leaf, enlarged: (11) Resin ducts near lower surface of leaf, (12) Resin ducts up in pulp of leaf, (13) *A. magnifica* and *shastensis,* (14) *A. nobilis.*

2. Bracts with short points, or occasionally without points (figs. 5 and 6).
a. Upper surface of leaf with stomata (text fig. 1*c*) .... (5) *A. concolor*
b. Upper surface of leaf without stomata (text fig. 1*a*) .... (6) *A. grandis*
B. Bracts oblong-ovate, gradually narrowing into short, stout points, shorter than cone-scales (fig. 8) .... (7) *A. magnifica*
C. Bracts spatulate, reflexed, longer than cone-scales.
1. Bracts with short points (fig. 9) .... (8) *A. shastensis*
2. Bracts with long, stout points (fig. 10) ..... (9) *A. nobilis*
D. Bracts produced into a long leaf-like awn, several times the length of the cone-scale (fig. 7) ..... (10) *A. venusta*

1. *Abies balsamea* (L.) Mill. (Balsam fir). Leaves flattened, one-half to 1¼ inches long, pointed, or sometimes emarginate at apex, with stomata on upper surface, and resin ducts large, up in pulp of leaf; cones 2 to 4 inches long, dark purple, with bracts ovate, shorter than cone-scales, with long slender points. A tree 50 to 70 feet high, or much reduced at high elevations and in Arctic regions. Newfoundland and Labrador to Hudson Bay and the Northwest Territory, south to Massachusetts, Pennsylvania, west to Michigan and Minnesota, and south along the Alleghanies to Virginia.

2. *Abies fraseri* (Pursh) Lindl. (Fraser fir). Leaves as in preceding; cones 2 to 2½ inches long, with spatulate reflexed bracts longer than cone-scales. A tree 30 to 40 or 70 feet high, 2 to 2½ feet in diameter. High Alleghanies of southwestern Virginia, western North Carolina, and eastern Tennessee.

3. *Abies lasiocarpa* (Hook.) Nutt. (Alpine fir). Leaves on lower branches 1 to 1¾ inches long, rounded or emarginate at apex, on upper branches one-half inch long, generally sharp pointed and thickened, stomata on upper surface, and resin ducts large, up in pulp of leaf; cones 2½ to 4 inches long, dark purple, with scales usually longer than broad and longer than the ovate, long and slender pointed bracts. A tree 80 to 100 feet high (sometimes 175 feet), 2 to 5 feet in diameter. At high elevations, along coast ranges, Alaska to Washington and Oregon, over all the high mountains, British Columbia and Alberta to Idaho, Wyoming, Colorado, Utah, Arizona, and New Mexico, assuming a light corky bark form in southern Colorado, in Arizona, and in New Mexico (*Abies arizonica* Merriam).

4. *Abies amabilis* Forbes (Amabilis fir). Leaves three-fourths to 1¼ inches long, without stomata on upper surface, with resin ducts

small, close to lower margin of leaf, leaves appearing to grow from both sides and the top of the twigs; cones 3½ to 6 inches long, deep purple, the bracts shorter than the cone-scales, with long, thickened points. A tree reaching 250 feet and a diameter of 4 to 6 feet. Portland Canal, Alaska, southward along the coast to Cascades in southern Oregon (Crater Lake), and on coast ranges of Oregon and Washington.

5. *Abies concolor* Lindl. (White fir). Leaves 2 to 3 inches long, on fertile branches three-fourths to 1½ inches long, two-ranked, with stomata on upper surface, and resin ducts small, close to lower margin of the leaf; cones 3 to 5 inches long, green, dark purple, or yellow, with ovate bracts shorter than cone-scales and with points short or wanting. A tree 200 to 250 feet high, 5 to 6 feet in diameter, becoming smaller inland. Northern Oregon, southward through the mountain ranges of California to Mt. San Pedro Martir, Lower California, and eastward through southern Idaho, Colorado, Arizona, New Mexico, and Chihuahua.

6. *Abies grandis* Lindl. (Lowland fir). Leaves 1½ to 2 inches long, flattened, spreading in two ranks, without stomata on upper surface or with few apical stomata, resin ducts small, close to lower surface of leaf; cones 2 to 4 inches long, not distinguished from the preceding. A tree 250 to 300 feet high, 3 to 4 feet in diameter, becoming smaller eastward. Vancouver Island south along the coast to Sonoma County, California, and east along the mountains of eastern Oregon and northern Washington and Idaho to the western slopes of the continental divide in western Montana, and to the Yellowstone National Park.

7. *Abies magnifica* A. Murr. (Red fir). Leaves four-sided, ridged above and below, stomatiferous on all sides, bluntly pointed, three-fourths to 1½ inches long, on lower branches spreading in two ranks, on upper and fertile branches thickened, crowded incurved and erect, completely hiding the upper side of the branches; resin ducts near lower surface of the leaf, but remote from the margins; cones dark purple-brown, 6 to 9 inches long, with bracts constricted at base, acute at apex, shorter than the cone-scales. A tree 175 to 200 feet high, 8 to 10 feet in diameter. Cascades of southern Oregon, mountain ranges of northern California, and southward throughout the western slopes of the Sierras.

8. *Abies shastensis* Lem. (Shasta fir). Leaves as in preceding; cones 5 to 6 inches long, purple or yellowish brown, with spatulate, short mucronate bracts slightly or conspicuously exserted and reflexed. A tree almost as large as preceding. Mountains of southern Oregon, where it is often confused with *Abies nobilis,* and down the Sierras to Kern County, California, where it is frequently reported as *Abies magnifica.*

9. *Abies nobilis* Lindl. (Noble fir). Leaves four-sided, grooved on

upper surface, slightly ridged below, stomatiferous on all sides, on lower branches 1 to 1½ inches long, flattened, rounded or notched at apex, on upper and fertile branches one-half to three-fourths inch long, thickened, four-sided, erect, incurved and acute at apex; resin ducts close to lower side of leaf, but remote from the margins; cones 4 to 5 inches long, purple or brown, with conspicuously exserted, reflexed, long-pointed bracts. A tree 150 to 200 feet high, 6 to 8 feet in diameter. Cascades of Washington to the Valley of the McKenzie River, Oregon, and in the coast mountains of Washington to the Siskiyous of northern California.

10. *Abies venusta* (Dougl.) Koch. (Silver fir). Leaves thin, flat, often falcate, with long, slender tips, 1½ to 2¼ inches long, with resin ducts close to lower side of leaf, and without stomata on upper surface; cones purplish brown, 3 to 4 inches long, with rounded scales and bracts prolonged into a flat-pointed awn 1 to 1¾ inches long. A tree 100 to 150 feet high, 2 to 3 feet in diameter. The rarest of our native firs, occurring in a few isolated groves on eastern and western slopes of the Santa Lucia Mountains in Monterey County, California.

NOMENCLATURE [1]

Abies

acutissima Hort. ex Beissn. = Picea canadensis (Mill.) B. S. P.
alba Chapm. = Picea mariana (Mill.) B. S. P.
alba Michx. = Picea canadensis (Mill.) B. S. P.
alba Torr. = Picea engelmanni Engelm.
alba var. arctica Parl. = Picea canadensis (Mill.) B. S. P.
Albertiana Murr. = Tsuga mertensiana (Bong.) Carr.
amabilis (Loud.) Forb. = Amabilis fir.
amabilis Hort. ex Beissn. = Abies concolor (Gord.) Parry.
amabilis Hort. ex Carr. = Abies magnifica Murr.
Americana Koch. = Picea mariana (Mill.) B. S. P.
Americana Mill. = Tsuga canadensis (L) Carr.
Americana alba Hort. ex Beissn. = Picea canadensis (Mill.) B. S. P.
Americana rubra Hort. ex Beissn. = Picea rubra (Poir.) Diet.
arctica Cunn. ex Gord. = Picea rubra (Poir.) Diet.
arctica Murr. = Picea mariana (Mill.) B. S. P.
arizonica Merriam = Abies lasiocarpa (Hook.) Nutt.
aromatica Raf. = Abies grandis Lindl.
balsamea (L.) Mill. = Balsam fir.
balsamea Bigel. = Abies concolor (Gord.) Parry.
balsamea var. fraseri Nutt. = Abies fraseri (Pursh) Lindl.
balsamea var. fraseri Spach. = Abies fraseri (Pursh) Lindl.
balsamifera Michx. = Abies balsamea (L.) Mill.

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[1] In consideration of the fact that only ten species of *Abies* are to be found in the United States, an exceedingly large number of plants are mentioned under the name "*Abies*" in botanical literature, and especially in the writings of early botanists. These authors did not confine the genus to the true firs, as is done today, but included the so-called "Silver-firs" (*Abies*), the "Spruce-firs" (*Picea*), the "Hemlock-firs" (*Tsuga*), the Douglas-firs (*Pseudotsuga*), and even the larches (*Larix*). The above check list of the nomenclature of the true firs has been prepared in the hope that it will enable the student to determine what plant is referred to, regardless of the name used. The name now used by the Forest Service is followed by its most commonly accepted English equivalent. Grateful acknowledgment is made to Dr. B. Daydon Jackson, Royal Botanic Gardens, Kew, London, for valuable assistance rendered by the "Index Kewensis" in the preparation of this check list.

bifolia Murr. = Abies lasiocarpa (Hook.) Nutt.
bracteata Hook and Arn. = Abies venusta (Dougl.) Koch.
Bridgesii Kell. = Tsuga mertensiana (Bong.) Carr.
californica Hort. ex Steud. = Pseudotsuga taxifolia (Poir.) Brit.
californica vera Hort. ex Beissn. = Abies concolor (Gord.) Parry.
campylocarpa Murr. = Abies magnifica Murr.
Canadensis Coop. = Tsuga mertensiana (Bong.) Carr.
Canadensis Michx. = Tsuga canadensis (L.) Carr.
Canadensis Mill. = Picea canadensis (Mill.) B. S. P.
Caroliniana Chapm. = Tsuga caroliniana (Bong.) Carr.
commutata Gord. = Picea engelmanni Engelm.
concolor (Gord.) Parry = **White fir.**
concolor Lindl. and Gord. = Abies concolor (Gord.) Parry.
concolor var. lasiocarpa = Beissn. = Abies concolor (Gord.) Parry.
concolor var. lowiana (Murr.) Lem. = Abies concolor (Gord.) Parry.
coerulea Booth. ex Loud. = Picea rubra (Poir.) Diet.
coerulea Forb. = Picea canadensis (Mill.) B. S. P.
coerulescens Hort. ex Koch. = Picea rubra (Poir.) Diet.
curvifolia Salisb. = Picea canadensis (Mill.) B. S. P.
denticulata Michx. = Picea mariana (Mill.) B. S. P.
Douglasii Lindl. = Pseudotsuga taxifolia (Poir.) Britton.
Douglasii var. taxifolia Loud. = Pseudotsuga taxifolia (Poir.) Brit.
Doumetti Hort. ex Beissn. = Picea mariana (Mill.) B. S. P.
Drummondi Hort. ex Gord. = Pseudotsuga taxifolia (Poir.) Brit.
Engelmanni Parry = Picea engelmanni Engelm.
Engelmanni glauca Veitch. = Picea pungens Engelm.
excelsa Fraseri Hort. ex Carr. = Abies balsamea (L.) Mill.
falcata Raf. = Picea sitchensis (Bong.) Trautv. and Mayer.
fraseri (Pursh) Lindl. = **Fraser fir.**
Fraseri Hudsoni Carr. = Abies balsamea (L.) Mill.
glauca Hort. ex Carr. = Picea canadensis (Mill.) B. S. P.
Gordoniana Carr. = Abies grandis Lindl.
grandis Lindl. = **Lowland fir.**
grandis Carr. = Abies concolor (Gord.) Parry.
grandis Engelm. = Abies lasiocarpa (Hook.) Nutt.
grandis Murr. = Abies amabilis (Loud.) Forb.
grandis var. densiflora Engelm. = Abies amabilis (Loud.) Forb.
grandis var. Lowiana Hoop. = Abies concolor (Gord.) Parry.
grandis oregona Beissn. = Abies grandis Lindl.
grandis var. pallida Mast. ex Lem. = Abies concolor (Gord.) Parry.
heterophylla Raf. = Tsuga mertensiana (Bong.) Carr.
Hookeriana Murr. = Tsuga pattoniana (Jeffr.) Engelm.
Hudsonia Bosc. ex Carr. = Abies balsamea (L.) Mill.
Hudsonica Carr. = Abies balsamea (L.) Mill.
humilis La Pyl. = Abies fraseri (Pursh) Lindl.
invalensis Hort. ex Carr. = Abies balsamea (L.) Mill.
lasiocarpa (Hook.) Nutt. = **Alpine fir.**
lasiocarpa Lindl. and Gord. = Abies concolor (Gord.) Parry.
laxa Koch. = Picea canadensis (Mill.) B. S. P.
Lowiana Murr. = Abies concolor (Gord.) Parry.
macrocarpa Vasey = Pseudotsuga macrocarpa (Torr.) Mayr.
magnifica Murr. = **Red fir.**
magnifica Engelm. = Abies nobilis Lindl.
magnifica var. shastensis Lem. = Abies shastensis Lem.
Mariana Mill. = Picea mariana (Mill.) B. S. P.
Marylandica Hort. ex Sarg. = Picea mariana (Mill.) B. S. P.
Menziesii Engelm. = Picea pungens Engelm.
Menziesii Lindl. = Picea sitchensis (Bong.) Trautv. and Mayer.
Merkiana Fisch. ex Parl. = Picea sitchensis (Bong.) Trautv. and Mayer.
Mertensiana Lindl. and Gord. = Tsuga mertensiana (Bong.) Carr.
microcarpa Lindl. and Gord. = Larix laricina (Du Roi) Koch.
microphylla Raf. = Tsuga mertensiana (Bong.) Carr.
minor Duh. ex Gord. = Abies balsamea (L.) Mill.
minuta Poir. = Picea rubra (Poir.) Diet.
mucronata Raf. = Pseudotsuga taxifolia (Poir.) Britton.

mucronata var. palustris Raf. = Pseudotsuga taxifolia (Poir.) Britton.

nigra Du Roi = Picea mariana (Mill.) B. S. P.

nigra Engelm. = Picea angelmanni Engelm.

nigra Mariana Hort. ex Beissn. = Picea mariana (Mill.) B. S. P.

nigra var. rubra Michx. = Picea rubra (Poir.) Diet.

nobilis Lindl. = Noble fir.

nobilis Engelm. = Abies magnifica Murr.

nobilis var. magnifica Mast. = Abies magnifica Murr.

nobilis oregona Beissn. = Abies nobilis Lindl.

Novœ-Angliæ Koch = Picea mariana (Mill.) B. S. P.

obliqua Bong. ex Gord. = Pseudotsuga taxifolia (Poir.) Britton.

obliquata Raf. ex Gord. = Pseudotsuga taxifolia (Poir.) Britton.

oregona Hort. ex Beissn. = Abies grandis Lindl.

Parryana Hort. ex Beissn. = Picea pungens Engelm.

Parsoniana Hort. ex Mast. = Abies concolor (Gord.) Parry.

Parsonii Hort. ex Sarg. = Abies concolor (Gord.) Parry.

Pattoniana Jeff. ex Murr. = Tsuga mertensiana (Bong.) Carr.

Pattoni Gord. = Tsuga mertensiana (Bong.) Carr.

Pattonii McNab = Tsuga mertensiana (Bong.) Carr.

pectinata Poir. = Picea rubra (Poir.) Diet.

pendula Poir. = Larix laricina (Du Roi) Koch.

religiosa Hook. and Arn. = Sequoia sempervirens (Lamb.) Endl.

rubra Poir. = Picea rubra (Poir.) Diet.

rubra var. arctica Lindl. and Gord. = Picea rubra (Poir.) Dict.

rubra var. violacea Endl. = Picea canadensis (Mill.) B. S. P.

shastensis Lem. = Shasta fir.

Sitchensis Lindl. and Gord. = Picea sitchensis (Bong.) Carr.

subalpina Engelm. = Abies lasiocarpa (Hook.) Nutt.

subalpina var. fallax Engelm. = Abies lasiocarpa (Hook.) Nutt.

taxiofolia Raf. = Tsuga canadensis (L.) Carr.

taxifolia var. patula Raf. = Tsuga canadensis (L.) Carr.

taxifolia Jeff. ex Gord. = Tsuga mertensiana (Bong.) Carr.

trigona Raf. = Picea sitchensis (Bong.) Carr.

venusta (Dougl.) Koch. = Bristle-cone fir.

virescens Hinterh. ex Nym. = Picea canadensis (Mill.) B. S. P.

Williamsonii Bridg. ex Gord. = Tsuga mertensiana (Bong.) Carr.

Williamsonii Newb. = Tsuga mertensiana (Bong.) Carr.

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IS ABNORMAL BRITTLENESS IN WOOD CAUSED BY A LACK OF SOME ESSENTIAL MINERAL ELEMENT IN THE SOIL?

BY HARRY D. TIEMANN

Contributed

Normally the strength of wood may be expressed as a function of the dry weight, almost irrespective of species, although this function is different for different kinds of strength, such as endwise compression, bending, shear, hardness, etc. These follow different laws, some varying directly with the density, others as a function of a higher or lower degree; but, given the dry density of a piece of wood, its strength may be closely approximated from general laws. Certain species, however, are somewhat anomalous in this respect.

It has frequently been observed that the wood from a single tree or from a certain part of the country is strikingly exceptional to the laws of strength and density; it is abnormally brittle and weak. For example, two pieces of oak of the same density of dry wood and of the same rate of growth will sometimes show a decided difference in strength and toughness, both being free from decay and free from defects; or it sometimes happens that a dense piece of wood is weaker than a less dense piece of the same species. Decay, even when invisible to the eye, may produce a decided weakening and brittleness, but the condition under consideration occurs in wood free from fungous growth, as shown by the microscope.

The cause of this abnormal weakness has heretofore been sought in some structural difference in the form of the cells or in some organic chemical difference in the wood substance, but nothing indicative of the cause has been discovered along these lines. Recently several thousand fiber-length measurements were made of different pieces of wood, but no direct relationship was discovered between strength and fiber length. The microscope reveals no significant difference in the structure between the strong and the weak specimens.

How, then, can this peculiar difference between two apparently similar pieces of wood be accounted for? It occurred to the writer that it might be due to the inorganic or mineral constituent of the wood substance produced by a deficiency of some one of the essential elements in the soil in which the tree grew, probably potash. A statement has been published that brittleness in the limbs of peach trees is due to a lack of potash in the soil. I have been unable to locate the authority for this statement or to obtain any information as to its correctness or falsity.

An attempt has recently been made at the Forest Products Laboratory to obtain some experimental data on a few specimens, and the results appear to substantiate our hypothesis. Two specimens of post oak, approximately 2 by 2 by 6 inches in size, six *Eucalyptus globulus* insulator pins, and six discs of hickory, 1 by 2 by 2 inches, were available. The chemical analyses of these specimens, their specific gravities, and strengths were as follows:

Species.	Average specific gravity dry wood.	Brittleness as indicated by work to maximum load.	Analysis per cent of dry weight of wood.	
			Ash.	K_2O.
Oak (post):		*Inch-lbs. per cu. in.*		
1 strong	.733	14.61	1.025	0.143
1 weak	.622	5.44	0.606	.122
Hickory (shagbark):				
3 strong	.699	61.2	1.159	.2866
3 weak	.632	17.8	.944	.1969
Eucalyptus globulus:		*Bending load.*		
3 strong	.823	1,385 pounds.	.542	Not determined.
3 weak	.653	745 pounds.	.386	Do.

While it is apparent from this table that in each case the stronger wood had the higher specific gravity, the difference is not sufficient to account for the difference in strength in any case. It should be noted also that the percentages of ash and of K_2O are based upon the dry weight of the wood; so the differences are therefore not caused by the differences in specific gravities.

This article is written for the purpose of presenting the hypothesis for discussion rather than as proof of its establishment. The data are too few to even justify calling it a theory, yet they certainly point strongly in that direction, and on account of the possible importance of the idea, should it prove to be a fact, any information or material for experiment will be welcomed. On account of the phenomena being exceptional rather than the rule, suitable material for experiment is difficult to obtain and must generally await occasional accidental discovery in working with other strength problems.

If it is true that a deficiency in available potash or any of the essential elements in the soil will cause brittle or weak timber, this fact would be of considerable importance in forest management.

REVIEWS

A Universal Classification of Plant Communities[1]

The much-discussed question of forest types receives a new light from Brockmann-Jerosch and Rubel's Universal Classification of Plant Communities and Tansley's keen analysis of this classification.

The Universal Classification is based on *physiognomy* alone rather than on habitat or underlying ecological factors. Physiognomy is here used in its broadest sense, including composition and all other observable external characteristics.

Brockmann-Jerosch and Rubel have four objections to the use of ecology as a basis of classification.

(1) First the ecological systems hitherto employed have been defective in that they recognize only one of several interacting factors, and they give for example Warming's arrangement of plant communities according to the water content of the soil. Tansley agrees that if we take one factor only we will get an unnatural result.

(2) The authors' second objection to an ecological classification "is that it requires detailed study and therefore cannot be used by travelers"; this would apply to our field use. But this objection, Tansley replies, is purely utilitarian, not scientific, and "natural classifications should have nothing to do with utilitarian criteria. This reply cannot settle the matter for American foresters, who, from the very nature of their practice, are forced to recognize the utilitarian point of view. In England and Germany forest types in their natural state do not exist; hence, even though we possessed a purely ecological classification based on ample data and correct in every respect, we would have to correlate it with a classification which could be readily used in the field. When the Forest Service standardized forest types this was one of the main points at issue and one of the compelling motives for basing the classification on forest cover. The so-called "physical type," depending, as it does, on but one factor, is too incomplete to be considered as based upon an ecological classification.

(3) The third objection of the authors to the ecological basis—that it involves hypotheses which later research may prove groundless—Tans-

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[1] Tansley, A. G. "A Universal Classification of Plant Communities," Journal of Ecology, Vol. 1, No. 1, pp. 27–42, reviewing Brockmann-Jerosch, H., and Rubel, E. "Die Einteilung der Pflanzengesellchaften nach ökologisch-physiognomischen Gesichtspunkten" Leipsig (W. Engelmann), 1912, 72 pp.

ley dismisses by saying that our present lack of data is no excuse for giving up thé attempt altogether and using an entirely different basis. Tansley's attitude is sound. Even though we require a system based on visible characteristics, and though we may admit that ecological classifications based on deficient ecological data are less accurate than "cover" classifications based on a reasonable knowledge of cover, yet we must agree with Tansley that at bottom a natural classification must be based on natural causes, and that we are not only justified, but compelled, to build up and examine hypotheses until we find some that hold.

(4) The fourth objection of the authors—that it is impossible to discover a single "most important" factor to use exclusively as a basis of classification—does not appear to Tansley to touch the main question at all. This has, however, proved one of the great stumbling-blocks heretofore, as witness the attempts of Warming and Graebner in Europe and of Merriam and Livingston in America. Each has picked out a single factor—moisture content of the soil in one case, content of nutritive salts in another, temperature in a third, and the ratio between precipitation and evaporation in a fourth. All these attempts have shown the absolute necessity of considering all factors in any thoroughgoing system of classification. But, although these attempts unquestionably show the difficulties encountered in drawing up a universal classification on an ecological basis, they do not serve as an argument against such a classification, provided the difficulties can be overcome.

Brockmann-Jerosch and Rubel, in spite of their four objections to using an ecological basis for classification, do subscribe to the universally accepted principle that, used in the broad sense, ecology and physiognomy are cause and effect. Physiognomy can therefore, they say, play a part only in so far as it is founded on ecology. Tansley asks how, when they expressly disavow the need for thorough ecological investigation before building up their universal classification, they can tell when physiognomy is founded on ecology and when it is not; but physiognomy has been found to be a reliable index of habitat. This point Hilgard[2] emphasises, and Shantz has recently worked out in detail for Great Plains.[3] There can be no question that the habitat of a sugar pine-yellow pine-incense cedar forest is different from that of a pure yellow-pine forest, and that the habitat of a yellow-pine forest is different from that of a juniper forest, even though no readily observable differences of habitat be found in either case. Is it then unjustifiable or unscientific to class these areas separately on the basis of composition until such time as an ecological investigation will show us the underlying cause of the difference? I think not.

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[2] Hilgard, E. W. "Soils," pp. 314, 490, and elsewhere. Macmillan, New York, 1912.

[3] Shantz, H. L. "Natural Vegetation as an Indicator of the Capabilities of Land for Crop Production in the Great Plains Area." U. S. Dept. Agr., Bureau of Plant Industry, Bul. 201, 1911.

Brockmann-Jerosch and Rubel conclude that causal relations are the principal aim of investigations of plant communities, and that ecology forms the basis of such investigations, but believe, for the reasons which they give and which Tansley attempts to refute, that "it is inadvisable to use such causal relations as a classificatory principle."

The stand taken by the authors on one side and by Tansley on the other recall the discussion of "forest types" which in 1913 waged so hotly in the Society of American Foresters.[4] Tansley stands for the purely scientific non-utilitarian point of view. Thorough research from this point of view will eventually, we feel confident, give a satisfactory classification of plant communities based on causal relations; but, until a vastly larger amount of ecological data have been accumulated, foresters, compelled by their daily practice to recognize the utilitarian point of view, must use a classification based upon readily distinguishable characteristics. That such characteristics are not meaningless, but an expression of underlying causes, we firmly believe; and, therefore, as ecological knowledge develops we feel that it will build a foundation under our present manifestly incomplete system and strengthen rather than destroy it.

A brief outline of the Brockmann-Jerosch, Rubel classification, particularly that part dealing with forests, will be of no little interest. The series of vegetation units employed is as follows: Type of Vegetation, Class of Formations, Group of Formations, Formation, Association, and Subassociation, in descending order of ecological value. The Types of Vegetation follow the broad division into grassland, forest, etc. The Classes of Formation represent the division of these broad types into broad classes; for example, forests which comprise all woody growth are divided into coniferous, deciduous, etc. The Groups of Formations represent the main divisions in a Class of Formations; for example, the class of deciduous woody growth is divided into a group deciduous in winter and a group deciduous during a hot, dry period. Our well-established timberland and woodland would comprise groups of formations, provided the coniferous classes were kept separate from the broadleaf classes. The Formation corresponds with our broad forest types; for example, beech forest, called *Fagion silvaticæ,* is a formation. The Association represents a more detailed division; for example, beech forest characterized by the presence of sycamore maple, called *Fagetum silvaticæ acerosum pseudoplatani,* is an association. Latin names are used, since, to be of universal application, either Latin or Greek must be employed, and the authors prefer Latin because it is the parent of the Romance languages and more widely taught than Greek. Formation names are taken from the plant genera by the use of the termination *ion,* as in *Fagion silvaticæ.* For Association names the termination *etum* is used, as in *Fagetum silvaticæ acerosum pseudoplantani,* and the name of the subordinate but characteristic plant used as an adjective. The name of any unit can be qualified by the addition of the genitive of the name of a subordinate unit. This gives an exceedingly simple and usable scheme, admitting of the addition from time to time of new units and the modification of others without destroying the system. Even Tansley admits that "this kind of nomenclature has great advantages, provided we can agree on the units, particularly of the formations." The fact that, as Tansley says, "agreement is far from being attained" is not, in our opinion, a serious objection to the system. Experience in the Forest Service has clearly shown that even among those who agree upon the basic principles of "forest types" agreement as to the types themselves is seldom complete and must generally be secured by compromise; yet the classification is not thereby destroyed.

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[4] **Society of American Foresters, Proceedings, April, 1913, Vol. 8, No. 1.**

The authors have carried their system only as far as Groups of Formation, giving, however, a few examples of Formations and Associations under each Group.

Four Types of Vegetation are recognized: I, *Lignosum,* "woody vegetation, in which there are several stories of vegetation, conditioned by the dominant trees or shrub"; II, *Protum,* "meadow, in which the dominant plants are herbaceous and the vegetation *closed"*; III, *Desertum,* "desert, in which the vegetation is open"; IV, *Plankton,* non-rooting microphytes living in water.

The Classes of Formation under each of these heads are taken up by Tansley in considerable detail and are well worth studying. We are here concerned chiefly with the *Lignosum* type. For the others, suffice it to say that we disagree with the placing of prairies under *Deserta* rather than under *Prata.*

The *Lignosum* type comprises the following six Classes of Formations: (1) *Pluvulignosa,* (2) *Laurilignosa,* (3) *Durilignosa,* (4) *Ericilignosa,* (5) *Deciduilignosa,* and (6) *Conilignosa.*

In this country we are concerned only with the four last classes, which we will glance at briefly. "In Durilignosa," states Tansley, "the dominant trees and shrubs have either sclerophyllous foliage or green axes functioning as leaves." The class is divided into the *Durisilvæ,* or sclerophyllous forest formations, and *Durifructicetæ,* or sclerophyllous scrub formations. The latter are represented in this country by the chaparral[5] of southern California. The *Durisilvæ* do not appear to be found here, unless the live oaks of the southeast might be so considered. These oaks, however, seldom form true forests. The *Ericilignosa* have no forests, being represented only by the *Ericifruticeta* Group of Formations, which are heaths dominated particularly by shrubs characterized by narrow, rolled-up leaves, such as characterize the *Ericaceæ* and *Epacridaceæ* families. The *Deciduilignosa,* as their name implies, are dominated by trees and shrubs which lose their leaves during a certain period of each year. They are divided into three Groups of Formations: (*a*) *Æstatisilvæ,* composed predominantly of trees which lose their leaves during the cold season; (*b*) *Æstatifruticeta,* deciduous shrubs; (*c*) *Hiemisilvæ,* forests which lose their leaves during the summer dry season.

The *Conilignosa* are dominated by trees or shrubs with needle-like foliage, the coniferæ, with broad or scalelike leaves, being included in the *Laurilignosa.* The class is divided simply into *Conisilvæ,* coniferous forests, and *Conifruticeta,* coniferous shrubs.

Of all the Classes of Formations the *Conilignosa* are the most important in the United States, and it is unfortunate that this class is one of the least satisfactory. The trouble is that the authors have assumed that the Coniferæ "form not only a taxonomic, but also a natural ecological and physiognomic group." It is surprising to see that Tansley allows this statement to pass unchallenged.

As a matter of fact, the Coniferæ, at least in the United States, form by no means a natural ecological or physiognomic group. The coniferous forests along the west slopes of the Cascade Mountains in Washington and Oregon differ ecologically from the coniferous forests of the mountains of Arizona and New Mexico more fundamentally than the coniferous white-pine forests of New England differ from the deciduous oak forests of the same region. The broad ecological differences existing between various coniferous forests have been well expressed by McDougal on his map of the vegetation of the United States, on which he distinguishes between mesophilous coniferous and zerophilous coniferous forests.

The author's Classes of Formations would, we believe, have been stronger if the zerophilous conifer forests had been placed with the *Laurilignosa* and the mesophilous conifers kept separate.

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[5] Plummer, F. G. U. S. Dept. Agr., Forest Service, Bul. 85, 1911.

For us the immediate significance of Brockmann-Jerosch and Rubel's system lies in its relation to the Forest Service classification of forest types and its suggestiveness for the future development of this classification. Both systems at bottom are built upon essentially the same principle, namely, the use of vegetative cover as an index of ecological factors or habitat, though there are flaws in each in this respect, and both recognize the underlying causes of vegetation as the true distinction between plant communities, although objecting to using these causes in a classification. We do not agree with Brockmann-Jerosch and Rubel that attempts at classification on a purely ecological basis should be altogether abandoned, but this does not affect the principle on which their Universal Classification is based.

The main difference between the two systems is that the Forest Service classification starts with the smaller unit, the association or forest type, and only touches upon the larger units in a general way, whereas the Universal Classification begins with the large units and subdivides them. Since the Universal Classification has been worked out as far as Groups of Formations, and that of the Forest Service, broadly speaking, as far as Formations, the two may be said to meet. Each therefore contains a wealth of suggestions for the other; the Universal Classification with reference to the basis for creating larger units, the Forest Service classification in supplying many details of value in classifying the smaller units.

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TREE GROWTH AND CLIMATE [1]

In a stately volume, superbly printed and illustrated, Dr. Huntington, who is Assistant Professor of Geography at Yale University, brings together a large amount of interesting information bearing on the question of climatic cycles or pulsations during the past 2,000 or 3,000 years.

The author seeks to determine the sequence and character of such variations on the basis of evidence in the drier portions of America from Guatemala on the south to Idaho on the north. He brings together data from the diverse fields of geology, archeology, history, and botany, and reaches the conclusion that during the past 3,000 years North America has been subject to pronounced climatic pulsations similar to those which appear to have taken place in Asia and other parts of the Old

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[1] "The Climate Factor as Illustrated in Arid America," by Ellsworth Huntington. Published by the Carnegie Institution of Washington, D. C., 1914, pp. 341, plates 12, maps 2, text cuts 90.

World; that, furthermore, the climate of the past appears to have been distinctly moister than that of the present.

What in the world, readers of the Proceedings will ask, has this to do with forestry? The relationship does seem remote, but is actually very close. Dr. Huntington has made the study of tree growth a means of securing data on the whole problem of climatic pulsations. His early studies in various countries of Asia had clearly pointed to climatic pulsations having a periodicity of hundreds or thousands of years. To test the universality of these conclusions, the author undertook investigations of the rainfall as measured by the growth of trees. Four chapters of the present volume are devoted to this subject, and it is these which are of prime interest to foresters, though the whole book will well repay reading (especially the chapters on "The Ancient People of the Southwest" and "The Climate of the Geological Past").

Of these four chapters the first (chapter 11, pp. 100-121) presents the results of a study by Dr. A. E. Douglass, of the University of Arizona, on the inter-relation of precipitation and the size of annual rings in western yellow pine. His results show that the ring thicknesses are proportional to the rainfall, with an accuracy of 70 to 82 per cent. He also points out an apparent relationship between tree growth and sunspot activity through the mediation of the weather, and on this basis argues an 11-year cycle.

The next chapter (No. 12, pp. 123-138) is entitled "The Correction and Comparison of Curves of Growth." In it Dr. Huntington presents data which are the result of coöperation with the Forest Service, especially in the southwestern district. In view of this fact it would be premature here to set forth more than the main conclusions. From the plotted curves of the annual diameter growth of 17 widely scattered species, Dr. Huntington deduces that the trees' growth is characterized by long and important cycles, having a periodicity of 100 years or 200 years and affecting all parts of the country. The curves from Maine and Idaho, California and Missouri, agree so closely that they point to simultaneous country-wide pulsations of climate.

In the next chapter (No. 13, pp. 139-156) Dr. Huntington describes his "Curve of the Big Trees," based upon original work with *Sequoia washingtoniana*. The work was begun in May of 1911 near Hume, Cal., and Portersville, Cal. It was continued in 1912. Stump analyses were made not on the *average* radius (as is customary in forest mensuration), but on the *best* radius; usually two and frequently three and four radii were measured.[2] Dr. Huntington says of this: "One of our chief difficulties lay in the fact that in bad seasons one side of a tree often fails to lay on any wood, especially in cases where a clump of trees grow together in the sequoias' usual habit, and the inner portions do not have a fair chance. Often we found a difference of 20 to 30 years in radii at right angles to one another, and in one extreme case one side of a tree 3,000 years old was 500 years older than the other, according to our count. All these things necessitated constant care in order that our results might be correct. Another trial lay in the fact that in spite of the extraordinary durability of the wood a certain number of decayed places are found, especially at the centers of the older trees, exactly the portions which one must desire to see preserved."

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[2] 108 on one radius; 234 on two radii; 89 on three; 18 on four; 2 on five—a total of 925 measurements, of which 785 were actually used.

A total of 462 trees were measured; 451 actually used. The age of the trees varied from 250 to 3,210 years—an average of 1,400 years. (What a rotation!) Ten of the trees date back to 686 years before Christ; 79 to 2,000 years ago.

In addition to the corrections for age and longevity described in the preceding chapter, Dr. Huntington found it necessary to make three other types of correction:

(1) Correction to offset error in counting rings.

(2) Correction to offset failure of tree to form complete rings each year.

(3) Correction to offset swelled butt of trees.

The first correction was determined by recounts; 46 remeasurements showed an average divergence of 5.7 rings per tree, or one-third of one per cent of the average age of the trees.[3] The negligible slightness of this error in trees of such great age is encouraging evidence of accuracy in stem analyses.

The second correction is far more difficult. Radii on different sides of a tree were often found to be of unequal age. Differences of one to five per cent between different sides of the same tree are not uncommon; more than half the trees, however, show differences of less than one per cent. Dr. Huntington explains that: "In the cases where there is a genuine difference it appears to be due to the fact that during bad years one side of a tree may not make any growth. This may be due simply to the fact that that side is shaded by other trees or is prevented from getting much nourishment because of the presence of great numbers of roots of other plants; or it may be due to injuries, such as the breaking off of branches or the ravages of fire."

Dr. Huntington figures by the law of averages that the average tree under 1,000 years old misses 12 rings at some point in its circumference; this is so small a number that it can be neglected where two or more radii were counted. In cases where only one radius was counted, the average reading is less than the true maximum by .48 per cent in trees under 1,000 years old; 1.08 per cent in the oldest trees. Hence a slight addition is necessary in those cases where only one radius was counted. This addition was evenly distributed throughout the life of the tree, and the added decade was given the mean value of the decade on either side of where it was inserted. Where two or more radial measurements are available, decades have been added to bring the lesser reading up to the greater one unless the difference exceeds 2 per cent when the lesser is discarded. Altogether the inserted decades amount to less than two-fifths per cent of the total; the curve back to 1,000 years ago is almost unaffected, and even for the older portions it means a change of only eight years.

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[3] Two other individuals who recounted these 46 measurements differed by 8.2 and 7.5 rings respectively per tree.

The third correction—that for swelled butt—was made necessary by the obvious effect of flaring at the base on the measurement of rings of growth. Even in 32 young trees having a diameter of not over 6 or 7 feet near the base and an age of not over 600 or 1,000 years, the horizontal distance along which measurements are made exceeds the actual distance at right angles to the rings by amounts varying from 3 to 16 percent; average, 7.6 per cent. If plotted without correction, the curve would be 8 per cent too high in comparison with earlier parts. With old trees this effect is even greater.

Another danger, that of undulating circumference at the base, was avoided so far as possible by taking the measurements from points half way between buttress and hollow.

To still further correct the curve and eliminate all non-climatic factors, Dr. Huntington assumes that the climatic pulsations in California have been essentially synchronous with those of Central Asia. These last are indicated by the fluctuations of the level of the Caspian Sea. On the basis of these levels the curve of the sequoias has been tilted to correspond. The essential features, however, the ups and downs which indicate climatic pulsations, are not changed thereby, either in position or in relative importance. The resultant curve[4] represents the nearest possible approximation to the actual curve of growth of the sequoias as it would be if it were uninfluenced by differences in the rate of growth of old trees and young, or by any other influences except those of climate.

In the following chapter (No. 14, pp. 157-174) Dr. Huntington interprets the sequoia curve. While there are many details of interest, it seems expedient to state only the salient conclusions.

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[4] Figure 50, p. 172 of the book.

The author first examines the relation of the growth of the sequoia to precipitation. He finds that the growth depends primarily upon the amount of rainfall, but almost equally upon its monthly distribution. The rainfall of any single year is only one of the factors which determine the amount of growth. Only by taking a period of three years or more can one form an accurate judgment as to the actual amount of growth which corresponds to a given rainfall. Where a longer period than five years is concerned, if due allowance is made for age, longevity, and other factors, the thickness of the rings of growth is dependent upon the amount and season of the rainfall. In the past this relation of precipitation and growth must have been essentially the same as at present. Therefore Dr. Huntington feels warranted in concluding that in the long curve of growth, extending back 3,000 years, high places indicate abundant moisture and low places indicate drought.

The time of the year in which the precipitation occurs is of prime importance. Early snows aid the growth of trees by keeping the ground almost unfrozen, and thus allowing the melting snow to sink in and thoroughly saturate the soil. In addition to this the absence of frost in the ground permits the trees to begin growing almost as soon as the snow disappears, and thus the growing season is lengthened. The effect of late snows and of spring rains is still more direct. In general the growth of the trees appears to be especially promoted in years when the storms begin early and continue late.

Dr. Huntington thus sums up his conclusion on this point: "Judging from what we have seen of the rainfall of today and of its relation to the growth of the sequoias, high portions of their curve seem to indicate periods when the winters were longer than now, when storms began earlier in the fall and lasted later into the spring, and when midwinter was characterized by the great development of a cold, continental, high-pressure area, which pushed the storms of the zone of prevailing westerly winds far down into subtropical regions, and thus caused subtropical conditions to invade what is now the zone of equatorial rains."

The curve of sequoia growth for the 3,200 years prior to 1900 is interpreted by Dr. Huntington in conjunction with a similar curve of climatic changes in Central and Western Asia. It is surprising how closely the two curves agree. At 950 B. C. both curves show a decided maximum; then for 250 and 275 years they swing downward and again upward, reaching maxima at 690 and 660 B. C. respectively. Next both curves drop to minimum in 600 B. C., and still another in 300 and 280

B. C. respectively. The fluctuations in the succeeding centuries are minor ones, but with a gradual descent of both curves from the beginning of the Christian Era until checked about 600 A. D.; whereupon there is another descent until, about 650 A. D., a low stretch of both curves is reached, and continues so until the next marked culmination, about 1000 A. D.

Another maximum occurs about 1325 A. D., followed by a pronounced drop about 1475; thenceforward there is no marked rise, but a fluctuating level,[6] until about 1850 the lowest point is reached, with only a slight recovery at the end of the curve in 1900.

From his data Dr. Huntington draws the following final conclusions:

(1) Important climatic pulsations have been in progress throughout the past 3,200 years. They have a length of centuries, but do not show any regular periodicity.

(2) The main climatic pulsations of the temperate portions of Central and Western Asia agree with those of the same latitude in Western America. Dr. Huntington adds: "If these two regions, 10,000 miles apart, thus agree, it seems probable that in regions lying in the same latitude and having the same seasonal distribution of rainfall similar changes must have taken place all around the globe, or at least over all the continents, while corresponding, although not necessarily similar, changes must have occurred in other latitudes."

(3) In general the average climatic conditions of 2,000 or 3,000 years ago were moister than those of today. This change has been subject to pulsations, but the general trend is toward greater aridity.

(4) The curve represents the approximate truth as to the climatic pulsations of temperate continental regions for the past 3,000 years.

In reviewing Dr. Huntington's work criticisms have purposely been omitted, for it seems better to present his findings without any comment. His conclusions are not to be lightly dismissed by those who have not carefully followed his reasoning. That there are weaknesses in his arguments he would be the first to admit, for, in his own words, "it is only a preliminary sketch—a pioneer attempt to elucidate a most complex subject. The necessity for visualizing conclusions in the form of a curve compelled the making of a large number of more or less important assumptions."

A. B. RECKNAGEL.

ITHACA, N. Y.,
AUGUST, 1914.

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[6] The highest points being about 1700, 1740, and 1800.

THE EFFECT OF FERTILIZERS ON NURSERY STOCK [1]

The experiments were conducted at two nurseries, in one with coniferous stock and in the other with hardwood stock.

The coniferous nursery, La Minelle, is located in Elieux N. Forest at an altitude of over 1,000 feet. It lies within a fir forest (*Abies pectinata*). The ground under the nursery was covered with a fir stand about 70 years old, which was cut in 1905. The soil in the nursery is sandy and poor in nutritious substances.

Both mineral fertilizers and manure were used. The following fertilizers were applied: Superphosphates, 16 to 18 per cent; potassium of nitrate, 95 per cent; potassium chloride, 75 to 80 per cent; lime.

The four fertilizers were applied all together—three together, two together, and each separately. As manure fertilizer, cow manure was used and applied to the soil separately and together with lime or with potassium chloride or with superphosphates. In all there were thus laid off 21 different plots, including the control plot, which was not fertilized. The mineral fertilizers and the manure were applied to the soil in the following quantities:

	Pounds per .025 acre.[2]
Potassium of nitrate	8.8
Superphosphates	11
Potassium chloride	4.4
Lime	22
Cow manure	660

Potassium of nitrate was applied partly before the seed was sown and partly after it germinated. In transplanting two-year-old seedlings the potassium of nitrate was always applied after transplanting. In the case of all other fertilizers they were applied in the nursery beds before sowing and in transplant beds before transplanting.

In the case of Norway spruce, the seed was sown on May 26, 1906; potassium of nitrate applied on May 25. The seedlings were transplanted April 18, 1908. In the fall of 1909 a number of seedlings were examined and the weight of 100 seedlings, dried at a temperature of 100 degrees centigrade, was determined separately for the roots, stem with branches, and needles. The results showed that the best effect upon Norway spruce was produced by lime. Apparently the superphosphate favorably affected the seedlings only because of its lime, of which there was very little in the soil (.65 per cent). The effect of potassium chloride (KCl) was not clearly shown. Potassium of nitrate and cow manure without lime (CaO) had a negative effect.

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[1] E. Gulf. Ann. de la Science Agron, No. 6, 1913.

[2] About 120 square yards.

In the spring of 1910 some seedlings from various plots were transplanted into new plots and different fertilizers applied. In 1912 the seedlings were pulled up and examined. The results were as follows:

1. The plants which were well developed in the nurseries grew also well after transplanting.
2. Lime, and to a lesser degree superphosphate, helped to increase the substance of the plants (the plants were thicker).
3. Potassium chloride did not have a beneficial effect and in some cases apparently caused the death of plants (when not enough lime or cow manure was mixed with it).
4. The application of potassium of nitrate by itself caused the plants to become bushy and the stem and branches very thin.

In the case of Scotch pine and fir the effect of the different fertilizers was about the same. The lime had a most beneficial effect, while potassium of nitrate was entirely useless and in some cases even injurious.

The hardwood nursery, Etang de Brin, was given over to observations upon the effect of different fertilizers upon the growth of ash and oak. The nursery is located at an altitude of about 720 feet in the Amance Forest on soil originally occupied by a virgin beach and oak forest, which was cut out in 1903. The top soil was almost black without any lime. It was rich in nitrogen and phosphoric acid, fairly rich in K_2O, and very poor in lime and magnesia. The same fertilizers were used except that instead of cow manure ammonium sulphate was used. In addition one plot was laid off to observe the effect of gypsum as a fertilizer. Ammonium sulphate and gypsum were applied in quantities of 8.8 pounds per .025 of an acre. The observations were confined to *Quercus sessiflora, Quercus penduculata,* and *Fraxinus excelsa.* From the observations so far made the author does not feel justified in making definite conclusions. He merely remarks that in 1911 the most sturdy plants were those which received a nitrogenous fertilizer.

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